CONTENTS

CONTENTS .... A-i

TABLES........ A-ix

A1 INTRODUCTION A1-1

A1.1 Control Format A1-1

A1.2 Data Deck Organization A1-1

A1.3 Title Card A1-2

A1.4 Comment Cards A1-2

A1.5 Data Cards A1-2

A1.6 Continuation Cards A1-3

A1.7 Terminator Cards A1-3

A1.8 Sequential Expansion Format A1-4

A1.9 Upper/Lower Case Sensitivity A1-4

A1.10 Data Card Requirements A1-4

A2 MISCELLANEOUS CONTROL CARDS A2-1

A2.1 Card 1, Developmental Model Control A2-1

A2.2 Card 100, Problem Type and Option A2-2

A2.3 Card 101, Input Check or Run Option A2-3

A2.4 Card 102, Units Selection A2-3

A2.5 Card 103, Restart Input File Control Card A2-3

A2.6 Card 104, Restart-Plot File Control Card A2-4

A2.7 Card 105, CPU Time Remaining and the Diagnostic Edit Card A2-5

A2.8 Card 110, Noncondensable Gas Species A2-6

A2.9 Cards 115 , Noncondensable Mass Fractions A2-6

A2.9.1 Card 115, Initial Mass Fraction for Each Noncondensable Gas Type........ A2-6

A2.10 Cards 120 through 129, Hydrodynamic System Control Cards A2-6

A2.10.1 Hydrodynamic System Card A2-7

A2.11 Cards 140 through 147, Self-Initialization Option Control Cards A2-7

A2.11.1 Card 140, Self-Initialization Control Card A2-7

A2.11.2 Cards 141 through 142, Self-Initialization Pump Controller and Identification Cards A2-7

A2.11.3 Cards 143 through 144, Self-Initialization Steam Flow Controller Identification Cards A2-8

A2.11.4 Cards 145 and 146, Self-Initialization Feedwater Controller Identification Cards A2-8

A2.11.5 Card 147, Pressure and Volume Control Component Identification

Card ... A2-9

A3 CARDS 200 THROUGH 299, TIME STEP CONTROL CARDS ... A3-1

A3.1 Card 200, Initial Time Value and User Controlled Time Step ... A3-1

A3.2 Cards 201 through 299, Time Step Control ... A3-1

A4 CARDS 301 THROUGH 399, MINOR EDIT REQUESTS ... A4-1

A4.1 General Quantities ... A4-1

A4.2 Component Quantities ... A4-2

A4.3 Volume Quantities ... A4-4

A4.4 Junction Quantities ... A4-7

A4.5 Heat Structure Quantities ... A4-9

A4.6 Reflood-Related Quantities ... A4-10

A4.7 Reactor Kinetic Quantities ... A4-10

A4.8 Control System Quantities ... A4-10

A4.9 Cards 2080xxxx, Expanded Plot Variables ... A4-11

A5 CARDS 400 THROUGH 799 OR 20600000 THROUGH 20620000, TRIP INPUT DATA ... A5-1

A5.1 Card 400, Trips Cancellation Card ... A5-1

A5.2 Card 20600000, Trip Card Series Type ... A5-1

A5.3 Cards 401 through 599 or 20600010 through 20610000, Variable Trip Cards ... A5-1

A5.4 Cards 601 through 799 or 20610010 through 20620000, Logical Trip Cards ... A5-2

A5.5 Card 600, Trip Stop Advancement Card ... A5-3

A6 CARDS 801 THROUGH 999, INTERACTIVE INPUT DATA ... A6-1

A7 CARDS CCCXXNN, HYDRODYNAMIC COMPONENTS ... A7-1

A7.1 Card ccc0000, Component Name and Type ... A7-1

A7.2 Single-Volume Component ... A7-1

A7.2.1 Cards ccc0101 through ccc0109, Single Volume X-Coordinate Volume Data ... A7-1

A7.2.2 Cards ccc0181 through ccc0189, Single-Volume Y-Coordinate Volume Data ... A7-3

A7.2.3 Cards ccc0191 through ccc0199, Single-Volume Z-Coordinate Volume Data ... A7-3

A7.2.4 Card ccc0131, Additional Laminar Wall Friction Card ... A7-4

A7.2.5 Card ccc0200, Single-Volume Initial Conditions ... A7-4

A7.3 Time-Dependent Volume Component ... A7-6

A7.3.1 Cards ccc0101 through ccc0109, Time-Dependent Volume Geometry Cards ... A7-6

A7.3.2 Card ccc0200, Time-Dependent Volume Data Control Word ... A7-8

A7.3.3 Cards ccc0201 through ccc0299, Time-Dependent Volume Data Cards A7-10

A7.4 Single-Junction Component A7-11

A7.4.1 Cards ccc0101 through ccc0109, Single-Junction Geometry Cards A7-11
A7.4.2 Card ccc0110, Single-Junction Diameter and CCFL Data Card A7-12
A7.4.3 Card ccc0111, Single-Junction Form Loss Data Card A7-13
A7.4.4 Card ccc0201, Single-Junction Initial Conditions A7-13

A7.5 Time-Dependent Junction Component A7-14

A7.5.1 Card ccc0101, Time-Dependent Junction Geometry Card A7-14
A7.5.2 Card ccc0200, Time-Dependent Junction Data Control Word A7-14
A7.5.3 Cards ccc0201 through ccc0299, Time-Dependent Junction Data Cards A7-15

A7.6 Pipe, Annulus Component A7-15

A7.6.1 Card ccc0001, Pipe, Annulus Information Card A7-16
A7.6.2 Cards ccc0101 through ccc0199, Pipe, Annulus X-Coordinate Volume Flow Areas A7-16
A7.6.3 Cards ccc1601 through ccc1699, Pipe, Annulus Y-Coordinate Volume Flow Areas A7-16
A7.6.4 Cards ccc1701 through ccc1799, Pipe, Annulus Z-Coordinate Volume Flow Areas A7-17
A7.6.5 Cards ccc0201 through ccc0299, Pipe, Annulus Junction Flow Areas A7-17
A7.6.6 Cards ccc0301 through ccc0399, Pipe, Annulus X-Coordinate Volume Lengths A7-17
A7.6.7 Cards ccc1801 through ccc1899, Pipe, Annulus Y-Coordinate Volume Lengths A7-17
A7.6.8 Cards ccc1901 through ccc1999, Pipe, Annulus Z-Coordinate Volume Lengths A7-17
A7.6.9 Cards ccc0401 through ccc0499, Pipe, Annulus Volume Volumes A7-18
A7.6.10 Cards ccc0501 through ccc0599, Pipe, Annulus Volume Azimuthal Angles A7-18
A7.6.11 Cards ccc0601 through ccc0699, Pipe, Annulus Volume Vertical Angles A7-18
A7.6.12 Cards ccc0701 through ccc0799, Pipe, Annulus X-Coordinate (Elevation) Changes A7-18
A7.6.13 Cards ccc2101 through ccc2199, Pipe, Annulus Y-Coordinate (Elevation) Changes A7-19
A7.6.14 Cards ccc2201 through ccc2299, Pipe, Annulus Z-Coordinate (Elevation) Changes A7-19
A7.6.15 Cards ccc0801 through ccc0899, Pipe, Annulus Volume X-Coordinate Friction Data A7-20
A7.6.16 Cards ccc2301 through ccc2399, Pipe, Annulus Volume Y-Coordinate Friction Data A7-20
A7.6.17 Cards ccc2401 through ccc2499, Pipe, Annulus Volume Z-Coordinate Friction Data A7-20
A7.6.18 Cards ccc2501 through ccc2599, Pipe, Annulus Volume Additional Laminar Wall Friction Data A7-20
A7.6.19 Cards ccc0901 through ccc0999, Pipe, Annulus Junction Loss

Coefficients A7-21
A7.6.20 Cards ccc1001 through ccc1099, Pipe, Annulus Volume X-Coordinate Control Flags A7-21
A7.6.21 Cards ccc2701 through ccc2799, Pipe, Annulus Y-Coordinate Control Flags A7-22
A7.6.22 Cards ccc2801 through ccc2899, Pipe, Annulus Z-Coordinate Control Flags A7-23
A7.6.23 Cards ccc1101 through ccc1199, Pipe, Annulus Junction Control Flags A7-23
A7.6.24 Cards ccc1201 through ccc1299, Pipe, Annulus Volume Initial Conditions A7-23
A7.6.25 Cards ccc2001 through ccc2099, Pipe, Annulus Initial Boron Concentrations A7-25
A7.6.26 Card ccc1300, Pipe, Annulus Junction Conditions Control Words A7-25
A7.6.27 Cards cc1301 through ccc1399, Pipe, Annulus Junction Initial Conditions A7-26
A7.6.28 Cards ccc1401 through ccc1499, Pipe, Annulus Junction Diameter and CCFL Data Cards A7-26
A7.6.29 Card ccc3001 through ccc3099, Pipe, Annulus Junction Form Loss Data Card A7-26

A7.7 Branch, Separator, Jetmixer, Turbine, or ECC Mixer Component A7-27

A7.7.1 Card ccc0001, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Information Card A7-29
A7.7.2 Card ccc0002, Separator Component Options Card A7-29
A7.7.3 Cards ccc0101 through ccc0109, Branch, Separator, Jetmixer, Turbine, Or ECC Mixer X-Coordinate Volume Data A7-29
A7.7.4 Cards ccc0181 through ccc0189, Branch, Separator, Jetmixer, or ECC Mixer Y-Coordinate Volume Data A7-31
A7.7.5 Cards ccc0191 through ccc0199, Branch, Separator, Jetmixer, or ECC Mixer Z-Coordinate Volume Data A7-32
A7.7.6 Card ccc0131, Additional Laminar Wall Friction Card A7-33
A7.7.7 Card ccc0200, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Volume Initial Conditions A7-33
A7.7.8 Cards cccn101 through cccn109, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Junction Geometry Card A7-35
A7.7.9 Cards cccn110, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Junction Diameter and CCFL Data Cards A7-37
A7.7.10 Cards cccn112, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Junction Form Loss Data Card A7-37
A7.7.11 Cards cccn201, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Junction Initial Conditions A7-38
A7.7.12 Card ccc0300, Turbine/Shaft Geometry Card A7-38
A7.7.13 Card ccc0400, Turbine Performance Data Card A7-38
A7.7.14 Card ccc0500, GE Separator Data. A7-39
A7.7.15 Card ccc0501, GE Separator First Stage Data A7-39
A7.7.16 Card ccc0502, GE Separator Second Stage Data A7-40
A7.7.17 Card ccc0503, GE Separator Third Stage Data A7-41
A7.7.18 Card ccc0600, GE Dryer Data A7-41

A7.8 Valve Junction Component A7-41

A7.8.1 Cards ccc0101 through ccc0109, Valve Junction Geometry Cards A7-41
A7.8.2 Card ccc0110, Valve Junction Diameter and CCFL Data Card A7-43
A7.8.3 Card ccc0111, Valve Junction Form Loss Data Card A7-44
A7.8.4 Card ccc0201, Valve Junction Initial Conditions A7-44
A7.8.5 Card ccc0300, Valve Type Card A7-44
A7.8.6 Cards ccc0301 through ccc0399, Valve Data and Initial Conditions A7-45
A7.8.7 Cards ccc0400 through ccc0499, Valve CSUBV Table A7-48

A7.9 Pump Component A7-49

A7.9.1 Cards ccc0101 through ccc0107, Pump Volume Geometry Cards A7-49
A7.9.2 Card ccc0108, Pump Inlet (Suction) Junction Card A7-50
A7.9.3 Card ccc0109, Pump Outlet (Discharge) Junction Card A7-52
A7.9.4 Card ccc0110, Pump Inlet (Suction) Junction Diameter and CCFL Data Card A7-52
A7.9.5 Card ccc0111, Pump Outlet (Discharge) Junction Diameter and CCFL Data Card A7-52
A7.9.6 Card ccc0112, Pump Inlet (Suction) Junction Form Loss Data Card A7-52
A7.9.7 Card ccc0113, Pump Outlet (Discharge) Junction Form Loss Data Card A7-53
A7.9.8 Card ccc0200, Pump Volume Initial Conditions A7-53
A7.9.9 Card ccc0201, Pump Inlet (Suction) Junction Initial Conditions A7-55
A7.9.10 Card ccc0202, Pump Outlet (Discharge) Junction Initial Conditions A7-55
A7.9.11 Card ccc0301, Pump Index and Option Card A7-55
A7.9.12 Cards ccc0302 through ccc0304, Pump Description Card A7-56
A7.9.13 Card ccc0308, Pump Variable Inertia Card A7-57
A7.9.14 Card ccc0309, Pump-Shaft Connection Card A7-57
A7.9.15 Card ccc0310, Pump Stop Data Card A7-58
A7.9.16 Cards cccxx00 through cccxx99, Single-Phase Homologous Curves A7-58
A7.9.17 Cards cccxx00 through cccxx99, Two-Phase Multiplier Tables A7-58
A7.9.18 Cards cccxx00 through cccxx99, Two-Phase Difference Tables A7-59
A7.9.19 Cards ccc6001 through ccc6099, Relative Pump Motor Torque Data A7-59
A7.9.20 Card ccc6100, Time-Dependent Pump Velocity Control Card A7-59
A7.9.21 Cards ccc6101 through ccc6199, Time-Dependent Pump Velocity A7-60

A7.10 Multiple Junction Component A7-60

A7.10.1 Card ccc0001, Multiple Junction Information Card A7-60
A7.10.2 Cards ccc0nnm, Multiple Junction Geometry Card A7-60
A7.10.3 Cards ccc1nnm, Multiple Junction Initial Condition Cards A7-62
A7.10.4 Cards ccc2nnm, Multiple Junction Diameter and CCFL Data Cards A7-62
A7.10.5 Card ccc3nnm, Multiple Junction Form Loss Data Card A7-63

A7.11 Accumulator Component A7-64

A7.11.1 Cards ccc0101 through ccc0109, Accumulator Volume Geometry Cards A7-64
A7.11.2 Card ccc0131, Additional Laminar Wall Friction Card A7-66
A7.11.3 Card ccc0200, Accumulator Tank Initial Thermodynamics Conditions A7-66
A7.11.4 Card ccc1101, Accumulator Junction Geometry Card A7-66

A7.11.5 Card ccc1102, Accumulator Junction Form Loss Data Card A7-67

A7.11.6 Card ccc2200, Accumulator Tank Initial Fill Conditions, Standpipe/Surgeline Length/Elevation, And Tank Wall Heat Transfer Terms A7-68

A8 CARDS 1CCCGXNN, HEAT STRUCTURE INPUT A8-1

A8.1 Card 1cccg000, General Heat Structure Data.. A8-1

A8.1.1 General Heat Structure Data Card A8-1
A8.1.2 Heat Structure Delete Card... A8-2

A8.2 Card 1cccg001, Gap Conductance Model Initial Gap Pressure Data........................ A8-2

A8.3 Card 1cccg003, Metal-Water Reaction Control Card... A8-3

A8.4 Card 1cccg004, Fuel Cladding Deformation Model Control Card A8-3

A8.5 Cards 1cccg011 through 1cccg099, Gap Deformation Data A8-3

A8.6 Card 1cccg100, Heat Structure Mesh Flags A8-4

A8.7 Cards 1cccg101 through 1cccg199, Heat Structure Mesh Interval Data (Radial)..... A8-4

A8.7.1 Format 1 .... A8-4
A8.7.2 Format 2 .... A8-4

A8.8 Cards 1cccg201 through 1cccg299, Heat Structure Composition Data (Radial) A8-4

A8.9 Card 1cccg300, Fission Product Decay Heat Flag A8-5

A8.10 Cards 1cccg301 through 1cccg399, Heat Structure Source Distribution Data (Radial) A8-5

A8.11 Card 1cccg400, Initial Temperature Flag A8-5

A8.12 Cards 1cccg401 through 1cccg499, Initial Temperature Data A8-6

A8.12.1 Format 1 (Word 1 on Card 1cccg400 = 0).. A8-6
A8.12.2 Format 2 (Word 1 on Card 1cccg400 = -1) A8-6

A8.13 Cards 1cccg501 through 1cccg599, Left Boundary Condition Cards...................... A8-6

A8.14 Cards 1cccg601 through 1cccg699, Right Boundary Condition Cards..................... A8-8

A8.15 Cards 1cccg701 through 1cccg799, Source Data Cards... A8-8

A8.16 Card 1cccg800, Additional Left Boundary Option A8-9

A8.17 Cards 1cccg801 through 1cccg899, Additional Left Boundary Cards...................... A8-9

A8.18 Card 1cccg900, Additional Right Boundary Option A8-10

A8.19 Cards 1cccg901 through 1cccg999, Additional Right Boundary Cards.................. A8-10

A9 CARD 60000000, RADIATION MODEL CONTROL CARD A9-1

A9.1 Card 6ss00000, Radiation Set Card.. A9-1

A9.2 Cards 6ssnn001 through 6ssnn099, Radiation Heat Structure Data.......................... A9-1

A9.3 Cards 6ssnn101 through 6ssnn199, Radiation View Factors A9-2

A10 CARDS 201MMMNN, HEAT STRUCTURE THERMAL PROPERTY DATA A10-1

A10.1 Card 201mmm00, Composition Type and Data Format.. A10-1

A10.2 Cards 201mmm01 through 201mmm49, Thermal Conductivity Data or Gap Mole Fraction Data A10-1

A10.2.1 Table Format.. A10-2
A10.2.2 Functional Format A10-2

A10.3 Cards 201MMM51 through 201MMM99, Volumetric Heat Capacity Data A10-3

A10.3.1 Table Format.. A10-3
A10.3.2 Functional Format A10-3

A11 CARDS 202TTTNN, GENERAL TABLE DATA A11-1

A11.1 Card 202ttt00, Table Type and Multiplier Data...A11-1

A11.2 Cards 202ttt01 through 202ttt99, General Table Data...A11-1

A12 CARDS 30000000 THROUGH 39999999, REACTOR KINETICS INPUT...................... A12-1

A12.1 Card 30000000, Reactor Kinetics Type Card... A12-1

A12.2 Card 30000001, Reactor Kinetics Information Card... A12-1

A12.3 Card 30000002, Fission Product Decay Information A12-2

A12.4 Cards 30000101 through 30000199, Delayed Neutron Constants A12-3

A12.5 Cards 30000201 through 30000299, Fission Product Decay Constants A12-3

A12.6 Cards 30000301 through 30000399, Actinide Decay Constants............................ A12-3

A12.7 Cards 30000401 through 30000499, Power History Data...................................... A12-4

A12.8 Feedback Input A12-4

A12.8.1 Cards 30000011 through 30000020, Reactivity Curve or Control Variable Numbers A12-4
A12.8.2 Cards 30000501 through 30000599, Density Reactivity Table................. A12-4
A12.8.3 Cards 30000601 through 30000699, Doppler Reactivity Table A12-5
A12.8.4 Cards 30000701 through 30000799, Volume Weighting Factors............... A12-5
A12.8.5 Cards 30000801 through 30000899, Heat Structure or SCDAP Component Weighting Factors A12-5
A12.8.6 Cards 30001701 through 30001799, Volume-Weighting Factors A12-6
A12.8.7 Cards 30001801 through 30001899, Heat Structure or SCDAP Component Weighting Factors A12-6
A12.8.8 Cards 300019C1 through 300019C9, Feedback Table Coordinate Data A12-7
A12.8.9 Cards 30002001 through 30002999, Feedback Table Data........................ A12-7

A13 CARDS 20300000 THROUGH 20499999, PLOT REQUEST INPUT DATA A13-1

A14 CARDS 205CCCNN OR 205CCCCN, CONTROL SYSTEM INPUT DATA A14-1

A14.1 Card 20500000, Control Variable Card Type A14-1

A14.2 Card 205ccc00 or 205cccc0, Control Component Type Card................................ A14-1

A14.3 Cards 205ccc01 through 205ccc98 or 205cccc1 through 205cccc8, Control Component Data Cards A14-2

A14.3.1 Sum-Difference Component A14-2
A14.3.2 Multiplier Component A14-3
A14.3.3 Divide Component A14-3
A14.3.4 Differentiating Components A14-3
A14.3.5 Integrating Component A14-4
A14.3.6 Functional Component A14-4
A14.3.7 Standard Function Component A14-5
A14.3.8 Delay Component A14-5
A14.3.9 Unit Trip Component A14-6
A14.3.10 Trip Delay Component A14-6
A14.3.11 Integer Power Component A14-6
A14.3.12 Real Power Component A14-7
A14.3.13 Variable Power Component A14-7
A14.3.14 Proportional-Integral Component A14-7
A14.3.15 Lag Component A14-8
A14.3.16 Lead-Lag Component A14-8
A14.3.17 Constant Component A14-9
A14.3.18 Shaft Component A14-9
A14.3.19 PUMPCTL Component A14-11
A14.3.20 STEAMCTL Component A14-11
A14.3.21 FEEDCTL Component A14-12

A15 CARDS 1001 THROUGH 1999, STRIP REQUEST DATA A15-1

A16 CARDS 1001 THROUGH 1999, COMPARE DUMP FILES CONTROL DATA A16-1

A17 RELAP5-BASED CODE OPERATING PROCEDURES A17-1

TABLES

A8.13-1. Card 501 and 601 Word 3 convection boundary type.................................... A8-7

A1 INTRODUCTION

This appendix completely describes data deck organization and data card requirements for all problem types allowed in RELAP5/MOD3.2.

A1.1 Control Format

Input is described in terms of input records or cards, where an input record or card is an 80-character record. Punched cards are nearly obsolete and one would be hard-pressed to find a key punch machine at most installations. Now, data are normally entered from interactive terminals, personal computers, or workstations, and the input usually exists only as disk files or is archived on tape. Data are usually viewed as lines on a CRT screen or lines of printed output. Nonetheless, the word card in used extensively in this input description to mean an input record.

RELAP5 attempts to read a 96-character record. If the actual input record is smaller, blank characters are added to the end of the input record to extend it to 96 characters. Each 96-character input record, preceded by a sequential card number starting at one and incrementing by one, is printed as the first part of a problem output. Only the first 80 characters are used for RELAP5 input; the additional 16 columns are for use with editors or utility programs such as UPDATE.

Most interactive editors allow the input of at least 80 character records. With many terminals allowing only 80 characters per line, it is convenient to limit the data record to 72 characters so that the data and editor supplied line numbers fit on one line (eight columns for line number and separator, 72 columns of data). Some editors provide for the optional storing of editor line numbers following the data portion of the record. If the data field is 72 columns, the line numbers might be stored in columns 73 to 80. These line numbers will be processed by RELAP5 as input, since RELAP5 uses the first 80 characters. To avoid this, either request the editor to store line numbers starting at character position 81, put a terminating character before the line number, or don’t store the line numbers. The line numbers, if saved, are listed in the output echo of the input data.

If the UPDATE program is used to maintain the input deck, the update command must be used to specify that the card data are 80 columns instead of the default of 72.

A1.2 Data Deck Organization

A RELAP5 problem input deck consists of at least one title card, optional comment cards, data cards, and a terminator card. A list of these input cards is printed at the beginning of each RELAP5 problem. The order of the title, data, and comment cards is not critical except that only the last title card and, in the case of data cards having duplicate data card numbers, only the last data card is used. We recommend that for a base deck, the title card be first, followed by data cards in card number order. Comment cards should be used freely to document the input. For parameter studies and for temporary changes, a new title card with the inserted, modified, and deleted data cards and identifying comment cards should be placed just ahead of the terminating card. In this manner, a base deck is maintained, yet changes are easily made.

When card format punctuation errors, such as an alphanumeric character in numeric fields are detected, a line containing a caret (^) located under the character causing the error and a message giving the card column of the error are printed. An error flag is set such that input processing continues, but the RELAP5 problem is terminated at the end of input processing. A standard RELAP5 error message (error message preceded by ********) is printed if a card error is found. Usually a card error will cause additional error comments to be printed during further input processing when the program attempts to process the erroneous data.

A1.3 Title Card

A title card must be entered for each RELAP5 problem. A title card is identified by an equal sign (=) as the first nonblank character. The title (remainder of the title card) is printed as the second line of the first page following the list of input data. If more than one title card is entered, the last one entered is used.

A1.4 Comment Cards

An asterisk (*) or a dollar sign ($) appearing as the first nonblank character identifies the card as a comment card. Blank cards are treated as comment cards. The only processing of comment cards is the printing of their contents. Comment cards may be placed anywhere in the input deck except before continuation cards.

A1.5 Data Cards

Data cards may contain varying numbers of fields that may be integer, real (floating point), or alphanumeric. Blanks preceding and following fields are ignored.

The first field on a data card is a card identification number that must be an unsigned integer. The value for this number depends upon the data being entered and will be defined for each type. If the first field has an error or is not an integer, an error flag is set. Consequently, data on the card are not used, and the card will be identified by the card sequence number in the list of unused data cards. After each card number and the accompanying data are read, the card number is compared to previously entered card numbers. If a matching card number is found, the data entered on the previous card are replaced by data from the current card. If the card being processed contains only a card number, the card number and data from the last previous card with that card number are deleted. Deleting a nonexistent card is not considered an error. If a card causes replacement or deletion of data, a statement is printed indicating that the card is a replacement card.

Comment information may follow the data fields on any data card by beginning the comment with an asterisk (*) or dollar ($) sign.

A numeric field must begin with either a digit (0 through 9), a sign (+ or -), or a decimal point (.). A comma or blank (with one exception, subsequently noted) terminates the numeric field. The numeric field has a number part and optionally an exponent part. A numeric field without a decimal point or an exponent is an integer field; a number with either a decimal point, an exponent, or both is a real field. A real number without a decimal point (i.e., with an exponent) is assumed to have a decimal point immediately in front of the first digit. The exponent part denotes the power of ten to be applied to the number part of the field. The exponent part has an E or D, a sign (+ or -), or both followed by a number giving the power of ten. These rules for real numbers are identical to those for entering data in FORTRAN E or F fields except that no blanks (with one exception) are allowed between characters to allow real data written by FORTRAN programs to be read. The exception is that a blank following an E or D denoting an exponent is treated as a plus sign. Acceptable ways of entering real numbers, all corresponding to the quantity 12.45, are illustrated by the following six fields:

12.45, +12.45, 0.1245+2, 1.245+1, 1.245E 1, 1.245D+1 .

Alphanumeric fields have three forms. The most common alphanumeric form is a field that begins with a letter and terminates with a blank, a comma, or the end of the card. After the first alphabetic character, any characters except commas and blanks are allowed. The second form is a series of characters delimited by quotes (“) or apostrophes (’). Either a quote or an apostrophe initiates the field, and the same character terminates the field. The delimiters are not part of the alphanumeric word. If the delimiter character is also a desired character within the field, two adjacent delimiting characters are treated as a character in the field. The third alphanumeric form is entered as nHz, where n is the number of characters in the field, and the field starts at the first column to the right of H and extends for n columns. With the exception of the delimiters (even these can be entered if entered in pairs), the last two alphanumeric forms can include any desired characters. In all cases, the maximum number of alphanumeric characters that can be stored in a word is eight. If the number of characters is less than eight, the word is left justified and padded to the right with blanks. If more than eight characters are entered, the field generates as many words as needed to store the field, eight characters per word, and the last word is padded with blanks as needed. Regardless of the alphanumeric type, at least one blank or comma must separate the field from the next field.

Note that the CDC-7600-6600 class of computers stores ten characters per word, while most other computers (e.g., CRAY, Cyber 205, and IBM) hold only eight characters per word. All alphanumeric words required by RELAP5, such as components types, system names, or processing options, have thus been limited to eight characters. We highly recommend that the user limit all other one-word alphanumeric quantities to eight characters so that input decks can be easily used on all computer versions. Examples of such input are alphanumeric names entered to aid identification of components in output edits.

A1.6 Continuation Cards

A continuation card, indicated by a plus sign (+) as the first nonblank character on a card, may follow a data card or another continuation card. Fields on each card must be complete, that is, a field may not start on one card and be continued on the next card. The data card and each continuation card may have a comment field starting with an asterisk (*) or dollar ($) sign. No card number field is entered on the continuation card, since continuation cards merely extend the amount of information that can be entered under one card number. Deleting a card deletes the data card and any associated continuation cards.

A1.7 Terminator Cards

The input data are terminated by a slash or a period card. The slash and period cards have a slash (/) and a period (.), respectively, as the first nonblank character. Comments may follow the slash and period on these cards.

When a slash card is used as the problem terminator, the list of card numbers and associated data used in a problem is passed to the next problem. Cards entered for the next problem are added to the passed list or act as replacement cards, depending on the card number. The resulting input is the same as if all previous slash cards were removed from the input data up to the last period card or the beginning of the input data.

When a period card is used as the problem terminator, all previous input is erased before the input to the next problem is processed.

A1.8 Sequential Expansion Format

Several different types of input are specified in sequential expansion format. This format consists of sets of data, each set containing one or more data items followed by an integer. The data items are the parameters to be expanded, and the integer is the termination point for the expansion. The expansion begins at one more than the termination point of the previous set and continues to the termination point of the current set. For the first set, the expansion begins at one. The termination points are generally volume, junction, or mesh point numbers, and always form a strictly increasing sequence. The input description will indicate the number of words per set (always at least two) and the last terminating point. The terminating point of the last expansion set must equal the last terminating point. Two examples are given. For the volume flow areas in a pipe component, the format is two words per set in sequential expansion format for nv sets. Using the number of volumes in the pipe (nv) as 10, the volume flow areas could be entered as

0010101 0.01,10 .

In this case, the volume flow areas for volumes 1 through 10 have the value 0.01.

The second example shows how the pipe volume friction data could be input. The input consists of three words per set for nv sets. The three words designate the wall roughness, hydraulic diameter (input of zero causes the code to calculate it), and volume number. Possible data might be

0010801 1.0-6,0,8 1.0-3,0,9

0010802 1.0-6,0,10 .

Here, volumes 1 through 8 and 10 have the same values, and volume 9 has a different value.

A1.9 Upper/Lower Case Sensitivity

Historically, computer systems allowed only upper case alphabetic characters. Accordingly, the following input descriptions use upper case for required input, e.g., SNGLVOL, 1.25E5. Now, many systems have upper and lower case alphabetic characters, and some applications are case sensitive, others not. At the INEL, required input must be in lower case, and the user should check the requirements at other installations. At installations with both upper and lower case capability, there are utilities and editors that can easily switch alphabetic characters to the desired case.

A1.10 Data Card Requirements

In the following description of the data cards, the card number is given with a descriptive title of the data contained on the card. Next, an explanation is given of any variable data that are included in the card number. Then, the order of the data, the type, and the description of the data item are given. The type is indicated by A for alphanumeric, I for integer, and R for real.

A2 MISCELLANEOUS CONTROL CARDS

A2.1 Card 1, Developmental Model Control

This card has been added to the code for the convenience of developers in testing model improvements or new models. This card is not a standard input feature of the code. The description of this card has been added to the input requirements because several laboratories are receiving test versions to assist in the development and testing of the code. Anyone using this card must realize that they are selecting experimental options still under development. Furthermore, these options may change more frequently that the revision of this input manual. Thus, before using the options, users should obtain the brief listing of current options from the code (described below) and verify those descriptions against this manual.

The purpose of this card is to allow developers and analysts to quickly test new models by activating or deactivating a model through simple input instead of program modification, compilation, and loading. Ninety logical variables having only false or true values are provided and defined at the start of program execution as false. This input sets the logical variables to true or resets them to false at the beginning of a new problem or at any restart. Fortran IF statements added as part of the experimental coding activate or deactivate models based on the values of the logical variables.

As described above, up to 90 options can be defined and the options are identified with a number from 1 through 90. Which options are defined and what they control are very much version dependent. The usual practice is to enter the option capability using a currently unused option number as the new model or improvement is first coded. During further development and testing, the model may change and the effect of the option can change in a manner ranging from large to subtle. When the model has been completed or even abandoned, the production version of the model is coded and the option capability is removed. The option number is then available for reuse with a completely different model. Thus, the options are version dependent as to what option numbers are in use, what models they control, and the particular features of the models. Accordingly, these options should be used only by those in direct contact with the developers.

Each current option is described below. In light of the discussion above, the user should verify that the code version being used corresponds to this description. Programmers using this option feature are asked to include coding that issues error messages when unused options are selected and to issue a brief statement of the purpose of selected options. Remember, however, that all coding associated with these options is experimental and these output conventions may not be thoroughly checked.

Up to 91 numbers consisting of 0 or any of the currently available option numbers may be entered on this card. A positive nonzero number, n, activates Option n by setting the logical variable n to true; a negative nonzero number, -n, deactivates Option n by setting the logical variable n to false. Attempting to activate an unused option is an error, and attempting to deactivate an already inactive option or an unused option is also an error. The status of the options is printed in any NEW or RESTART problem containing this card or a RESTART problem in which the restart point had an option selected. The printout includes a listing of the 90 option numbers and a false (option not selected) or a true (option selected) value plus the brief description of each selected option.

The number 0 is not an option number but may be entered to force the brief descriptions of all available options to be printed regardless of whether they are active. The 0 input should be used only once to observe the available options and then removed so that the list better emphasizes the selected options.

W1-20(I) Zero or an available option number as described above.

Option 23. This options selects a boron transport algorithm that greatly reduces the numerical diffusion of boron compared to the standard algorithm.

Option 37. This option turns off the umbrella model. When the umbrella model is on, an upper limit is placed on the liquid interfacial heat transfer coefficient (H_{if}) when the liquid is subcooled. The limit is umbrella shaped so as to force the coefficient to small values as the void fraction approaches 0.0 or 1.0.

Option 51. Normally, water packing is activated in all volumes unless specifically disabled by an input volume flag. This option disables water packing for all volumes.

Option 52. Normally, the choking model is activated for all junctions unless specifically disabled by an input junction flag. This option disables the choking model for all junctions.

A2.2 Card 100, Problem Type and Option

This card is always required.

W1(A) Problem type. Enter one of the following: NEW, RESTART, PLOT, REEDIT, STRIP, or CMPCOMS.

NEW specifies a new simulation problem. NEWATH must be used for ATHENA problems. ATHENA provides hydrodynamic fluids in addition to light and heavy water; access to these fluids require the use of NEWATH in place of NEW. RESTART specifies continuation from some point in a previous problem using information from the RSTPLT file. PLOT specifies plotting results from a previous simulation run using the RSTPLT file. REEDIT has not been implemented. STRIP specifies that data are to be extracted (stripped) from the RSTPLT file, and only the data specified are written to the STRIP file. CMPCOMS specifies that a comparison is to be made between dump records on two files written in one or two previous runs.

W2(A) Problem option. This word is needed if W1 is NEW or RESTART and is optional if W1 is STRIP. If NEW or RESTART is entered, enter either STDY-ST or TRANSNT to specify the type of simulation. Note the cautions discussed in Section A2.5 when the problem option is changed from STDY-ST to TRANSNT or vice versa. When STRIP is entered in W1, W2 may be optionally entered with BINARY or FMTOUT. BINARY is assumed if W2 is not entered. BINARY indicates the unformatted (BUFFER OUT) file. FMTOUT indicates that the same information is to be written as 80-column formatted records. One use of this option is to allow simulation results to be transmitted to a different type of computer. Formats are

STRIP Record 1. (5A8,10X,A8)

STRIP Record 2. (A10,3I10)

STRIP Record 3. (8A10)

STRIP Record 4. (A10,7I10/(8I10))

STRIP Record 5..., N. (A10, 5X,1P,4E15.6/(5E15.6)).

The STRIP record above refers to the data in one record of the unformatted file. Multiple 80-column formatted records may be written for STRIP Records 3 through n.

A2.3 Card 101, Input Check or Run Option

This card is optional for all types.

W1(A) Option. Enter either INP-CHK or RUN; if this card is omitted, RUN is assumed. If INP-CHK is entered, the problem execution stops at the end of input processing; if RUN is entered, the problem is executed if no input errors are detected. This card has no effect on a CMPCOMS problem.

A2.4 Card 102, Units Selection

This card is optional for all problem types. If the card is omitted, SI units are assumed for both input and output. If the card is used, enter either SI or BRITISH for each word. SI units used are the basic units, kg, m, s, and the basic combined units such as Pa = kg•m/s^2•m^2. British units are a mixture of lb (mass), ft, and s primarily, but pressure is in lb_f/in^2 (lb_f is pounds force), heat energy is in Btu, and power is in MW. Thermal conductivity and heat transfer units use s, not h.

W1(A) Input units.

W2(A) Output units. If this word is missing, SI units are assumed for output.

A2.5 Card 103, Restart Input File Control Card

This card is required for all problem types (W1 of Card 100) except NEW and is not allowed for type NEW.

When the problem option (W2 on Card 100) is the same as the problem being restarted, the steady state or transient is continued, and data on the RSTPLT file up to the point of restart are saved. If the restart continues from the point the previous problem terminated, restart and plot information is added to the end of the previous RSTPLT file. If the restart is prior to the termination point of the previous simulation, restart and plot data after the point of restart are overwritten by new results. A copy should be saved if RSTPLT files from each simulation are needed. If the problem options are different, data up to the point of restart are not saved, problem advancement time is reset to zero, and the RSTPLT file will contain information as if this problem type were NEW.

Some cautions should be observed when the problem advancement time is changed by changing the problem option from STDY-ST to TRANSNT, or vice versa, or the problem advancement time is reset through W1 on Card 200. Either or both of these could be specified at restart. When the advancement time is changed, the user is responsible for ensuring that models involving problem time will operate as intended. Affected models include trips using advancement time, control systems using time as an operand (does not include differentiation or integration with respect to time), and table lookup and interpolation using time as the independent variable. If necessary, trips, control systems, general tables, time-dependent volumes, junctions, and pump speed tables can all be reentered at restart. With normal modeling practices, little use of modeling features involving advancement time is needed for runs to steady state and accordingly little effort should be needed in switching from STDY-ST to TRANSNT. Because of the frequent use of time in logic to initiate failures, as part of safety systems, and used in establishing the delay times allowed in most table lookup and interpolation tables, required changes to a transient run may be extensive.

The program does make a change to delay control components when the advancement time is changed. The delay control component operates by maintaining a tabular past history of the delayed functions and using table lookup and interpolating to evaluate the delayed function. The table consists of pairs of time values and the delayed function. When the problem time is changed, the time values in the history table and the time value to store the next point in the table are modified by adding the difference of the new advancement time and the old advancement time. The modified history table is as if the problem being restarted was run with the new advancement time. This may not be the desired change, and, in that case, the user can reenter the delay component.

W1(I) Restart number. This must be a number printed in one of the restart print messages and whose associated restart information is stored in the RSTPLT file. If the problem type (W1 on Card 100) is STRIP, this number must be 0.

W2(A) Compress flag. This optional flag indicates whether the restart-plot file is written in a noncompressed or compressed format. If the word is not entered or if NCMPRESS is entered, the restart plot file is assumed to be in noncompressed format. If CMPRESS is entered, the restart plot file is assumed to be in compressed format.

W3-7(A) Restart plot file name. This optional alphanumeric entry can be used to enter the file name of the restart plot file. Up to forty characters may be entered as one alphanumeric field. (The code internally treats the field as up to five eight-character words.) The default file name for the restart plot file is rstplt. This may be overridden on Unix machines by using the -r option on the command line. Either the default name, the name from the command field, or the name from this field on a previous case may be overridden by this field.

A2.6 Card 104, Restart-Plot File Control Card

This card can be entered for NEW, RESTART, and STRIP options. For the strip option, this card controls the strip file, and the NONE option is not allowed. If this card is omitted, the restart-plot file is rewound at the end of the problem, but no further action is taken. The user may need to provide system control cards to dispose of the file. To prevent the restart-plot file from being written, a card with NONE must be entered.

W1(A) Action. This word may not be blank. If the card is NONE, no restart-plot file is written. If this word is NCMPRESS, the restart-plot file is written in noncompressed format. If this word is CMPRESS, the file is written in compressed mode. The NCMPRESS and CMPRESS options may be entered only in NEW problems. In RESTART problems, this information is entered on the 103 card.

W2-6(A) Restart plot file name. This optional alphanumeric entry can be used to enter the file name of the restart plot file. Up to forty characters may be entered as one alphanumeric field.

(The code internally treats the field as up to five eight-character words.) The default file name for the restart plot file is rstplt. This may be overridden on Unix machines by using the -r option on the command line. Either the default name, the name from the command field, or the name from this field on a previous case may be overridden by this field. This information can be entered only on NEW problems; in RESTART problems, this information may be entered on the 103 card.

A2.7 Card 105, CPU Time Remaining and the Diagnostic Edit Card

Card 105 controls termination of the transient advancement based on the CPU time remaining for the job. Some operating systems allow specification of the CPU time allocated for a job as part of the job control language and also provide a means to determine the CPU time remaining during job execution. As an alternative, Word 3 of this card may be entered as the CPU time allocated. An alternative CPU remaining time is computed by decrementing this quantity by the CPU used as measured by the program. If Word 3 is omitted or zero, the alternative CPU remaining time is assumed infinite. At the end of each time step, the CPU time remaining for the job is determined from the minimum of the system (if available) and alternative CPU remaining times. If the remaining CPU time is less than Word 1, the transient is immediately terminated. The advancement may not be at the end of a requested time step due to time step reduction; the hydrodynamic, heat conduction, and reactor kinetics may not be advanced to the same point; or the advancement may not be successful and the advancement is scheduled to be repeated with reduced time step. Major edits, minor edits, plot edits, and a restart record are forced. The transient can be restarted from this point as if the problem had not been interrupted. The transient is also terminated after successful advancement over a requested time step and the CPU time is less than Word 2. Word 2 should be larger than Word 1. The default values for Words 1 and 2 are 1.0 and 2.0 seconds. The default values are used if the card is not supplied or the entered numbers are less than default values. Word 2 is also forced to be 1.0 seconds larger than Word 1. The time values must include time for the final minor and major edits (very little time required), plotting, and any other processing that is to follow termination of SCDAP execution. This card is optional, but we strongly recommend its use with Word 3 nonzero on systems that do not provide a system CPU limit.

Card 105 also controls the diagnostic edit printout through the use of Words 4 and 5. If these words are missing or zero, no debug options are in effect. If Word 4 is greater than zero, then Word 4 is the attempted advancement count number to start a diagnostic edit, and Word 5 is the attempted advancement count number to stop the diagnostic edit as well as the calculation. If Word 4 is -1, a dump file is written on the file specified by the -A option on the command line at the completion of the advancement given in Word 5. Entering 0 in Word 5 writes the dump file just before the start of transient advancement. The problem is terminated after writing the dump file. If Word 4 is -2, a dump file is written on the file given by the -A option after the advancement given in Word 5; the time advancement is then repeated and a dump file following the repeated advancement is written on the file given by the -B option. The problem is terminated after writing the second dump file. Word 5 must be greater than 0 when Word 4 is -2. The default file names are -A dumpfil1 and -B dumpfil2.

W1(R) CPU remaining limit 1 (s).

W2(R) CPU remaining limit 2 (s).

W3(R) CPU time allocated (s). This quantity is optional.

W4(I) Debug control word as described above.

W5(I) Debug control word as described above.

If the program is compiled with compile time option CTSS defined, entering Word 1 as 0.0 will cause no testing for CPU termination and normal CTSS termination at the end of CPU time can occur. In this case, the problem can be restarted.

A2.8 Card 110, Noncondensable Gas Species

This card is required for all calculations that use noncondensable gas. Nitrogen must be included for any problem having accumulators or specifying noncondensables in initial conditions or time-dependent volumes.

W1-WN(A) Noncondensable gas type. Enter any number of words (maximum 5) of the following noncondensable gas types: argon, helium, hydrogen, nitrogen, xenon, krypton, air, or sf6.

A2.9 Cards 115 , Noncondensable Mass Fractions

Card 115 is related to Card 110. Card 115 is required if Card 110 is entered unless only one species is entered on Card 110, and then the mass fraction is set to 1.0. The number of words on Card 115 must equal the number of words on Card 110. The sum of the mass fractions on each card must sum to one. The mass fractions on these cards are default values and are used for initial conditions of active volumes and for values of time-dependent volumes unless mass fractions are entered in the hydrodynamic component data.

A2.9.1 Card 115, Initial Mass Fraction for Each Noncondensable Gas Type

This card is required if Card 110 is entered, unless only one species is entered on Card 110 and then the mass fraction is set to 1.0. The number of words on Card 115 must equal the number of words on Card 110. This card cannot be entered on a RESTART problem.

W1-WN(R) Mass fraction for each noncondensable gas type.

A2.10 Cards 120 through 129, Hydrodynamic System Control Cards

Independent hydrodynamic systems can be described by the hydrodynamic component input. The term independent hydrodynamic systems means that there is no possibility of flow between the independent systems. A typical example would be the primary and secondary systems in a reactor where heat flows from the primary system to the secondary system in the steam generator but there is no fluid connection. If a tube rupture were modeled, the two systems would no longer be independent. Input processing lists an elevation for each volume in each independent hydrodynamic system and includes a check on elevation closure for each loop within a system. A reference volume is established for each system through input or default.

The processing for elevation changes and checks on proper loop closure is extended for moving problems. An elevation change in a volume is the component on the fixed z axis of a movement from one face of the volume to the opposite face. In a fixed problem, the only body force is gravity along the negative z axis. With translational and rotational movement, additional body forces with components in all three directions are possible. Analogous to elevations changes, the components along each fixed axis due to the face to face movements along each coordinate direction in a volume are required. In moving problems, the loop closure test and associated edited output is done for all three fixed axes.

These cards are optional for each system but these cards will be needed for most moving problems. If not entered for a system, that system contains H_2O as the fluid unless a different fluid is specified in hydrodynamic component data, and the lowest numbered volume in each system is the reference volume. Additionally, the reference volume has a default elevation of zero for fixed problems and position coordinates of zero for a moving problem. These cards should not be entered in a RESTART problem.

In fixed problems, the ability of entering a reference elevation is only a user convenience to perhaps facilitate checking edited elevation data against facility drawings. In moving problems, the information is used in computing rotation effects. The specification of the position coordinates of the reference volume implies an origin, and using volume input information, the position coordinates of each volume in the system. The rotation is assumed to be about the origin implied by the position of the reference volume. The position coordinates of each volume are updated each time step and the position data can be plotted or printed in minor edits. The effects of translation are included when computing forces on the fluid within a volume but are not included in the computation of position coordinates. Thus during rotation and translation, the coordinates may change but the magnitude of the position vector remains constant.

A2.10.1 Hydrodynamic System Card

W1(I) Reference volume number. This must be a volume in the hydrodynamic system.

W2(R) Reference elevation of the volume center relative to a fixed z axis (m, ft).

W3(A) Fluid type. Enter H2O or D2O.

W4(A) Optional alphanumeric name of system used in output editing. *NONE* is used if this word not entered.

A2.11 Cards 140 through 147, Self-Initialization Option Control Cards

These cards are optional, are not needed, and are only used as a cross-check on the controllers specified in Section A14. Data supplied on these cards are used to invoke the self-initialization option. These data describe which and how many of each controller will be used. To retain generality and flexibility, the self-initialization option does not require that the steady state and nearly implicit solution scheme options be concurrently turned on. However, this is the recommended procedure. These latter options are invoked through input data Cards 100 and 201 through 299. In addition to the data cards described below, the user must furnish data on the controllers to be used, as described in Section A14.

A2.11.1 Card 140, Self-Initialization Control Card

This card specifies the number and type of controllers desired.

W1(I) Number of pump controllers.

W2(I) Number of steam flow controllers.

W3(I) Number of feedwater controllers.

A2.11.2 Cards 141 through 142, Self-Initialization Pump Controller and Identification

Cards

These cards establish the relationship between the pump number and the number of the pump controller. For each pump so referenced, the user *must* use the time-dependent pump velocity option. For pump component Card ccc6100, Words 2 and 3 must be the alphanumeric and numeric parts for the pump controller. The time-dependent pump velocity data (pump component Cards ccc6100 through ccc6199) should be input so that the search variable and pump velocity are related by a straight line through the origin with a slope of 1.

W1(I) Component number of pump number

W2(I) Controller identification number for pump number 1

W3(I) Component number of pump number 2

W4(I) Controller identification number for pump number 2.

A maximum of six pump/controller pairs may be entered.

A2.11.3 Cards 143 through 144, Self-Initialization Steam Flow Controller Identification Cards

These cards establish the relationship between the steam flow control valve number and the steam flow controller number.

W1(I) Component number of steam flow control valve number 1

W2(I) Controller number of steam flow controller for steam flow control valve number 1

W3(I) Component number of steam flow control valve number 2

W4(I) Controller number of steam flow controller for steam flow control valve number 2.

A maximum of six control valve/controller pairs may be entered. Note that in the above the valve component is assumed to be the control component. However, the user is not constrained to use a valve and may use a pump or a time-dependent junction. CAUTION: only a servo valve, a time-dependent junction, or a pump may be used, or a diagnostic error will result.

A2.11.4 Cards 145 and 146, Self-Initialization Feedwater Controller Identification Cards

These cards establish the relationship between the feedwater valve number and the feedwater controller number.

W1(I) Component number of feedwater valve number 1

W2(I) Controller id number of the feedwater controller for feedwater valve number 1

W3(I) Component number of feedwater valve number 2

W4(I) Controller id number of the feedwater controller for feedwater valve number 2.

A maximum of six control valve/controller pairs may be entered. Note that in the above it is assumed that a valve component is the control component. However, the user is not constrained to use a valve and may use a pump or time-dependent junction. CAUTION: only a servo valve, time-dependent junction, or a pump is allowed, or a diagnostic will result, such as a time-dependent junction with the controller output used as the independent variable in place of time.

A2.11.5 Card 147, Pressure and Volume Control Component Identification Card

This card identifies the component number, connection data, and pressure level for the time-dependent volume that is to provide pressure and volume control during the self-initialization null transient.

W1(I) Component number of time-dependent volume that replaces the pressurizer

W2(I) Component number to which the above time-dependent volume is connected; CAUTION: only a single junction is allowed or an error will result

W3(R) Desired steady state pressure.

A3 CARDS 200 THROUGH 299, TIME STEP CONTROL CARDS

A3.1 Card 200, Initial Time Value and User Controlled Time Step

This card is optional. See the description of each word on this card for the default values if this card is not entered.

W1(R) Initial time. If not entered, the simulation time at the start of the advancements is zero for a NEW problem, the advancement time at the point of restart for a RESTART problem, or zero for a RESTART problem in which the problem option switches from STDY-ST to TRANSNT or vice versa. If this card is entered, the simulation time is set to the entered value, which must be greater than or equal to zero. Setting the simulation time with this entry can be done on any NEW or RESTART problem but with most applications should only be used in NEW or RESTART problems that switch from the STDY-ST or TRANSNT options. See the cautions discussed in Section A2.5 for this capability. When needing to enter W2 but do not wish to enter a new initial time, enter -1.0, which is a flag to ignore this word.

W2(I) Control variable number for user controlled time step. This word is optional. A nonzero number specifies a control variable whose value is used for user-specified time step control. The time step will be determined from the maximum of the value of the control variable and the current minimum time step entered on Cards 201 through 209. The time step will be equal to or less than this value and depends on the current requested time step, the mass error and other error checks, the Courant limit, and the time-step reduction options.

A3.2 Cards 201 through 299, Time Step Control

At least one card of this series is required for NEW problems. If this series is entered for RESTART problems, it replaces the series from the problem being restarted. This series is not used for other problem types. Card numbers need not be consecutive.

W1(R) Time end for this set (s). This quantity must increase with increasing card number.

W2(R) Minimum time step (s). This quantity should be a positive number $\leq$ 1.0E-6. If a larger number is entered, it is reset to 1.0E-6.

W3(R) Maximum time step (s). This quantity is also called the requested time step. In transient problems (Word 2 = TRANSNT for Card 100), the user should be careful not to make this too large for the first time step.

W4(I) Control option (see Section 8.2 for a discussion of this input). This word has the packed format <u>ssdtt</u>. It is not necessary to input leading zeros.

The digits <u>ss</u>, that represent a number from 0 through 15, are used to control the printed content of the major edits. The number is treated as a four-bit binary number. If no bits are set (i.e., the number is 0), all the standard major printed output is given. If the first bit from the right is set (i.e., <u>ss</u>=1 if the other bits are not set), the heat structure temperature block is omitted. If the second bit from the right is set (i.e., <u>ss</u>=2 if the other bits are not set), the second portion of the junction block is omitted. If the third bit from the right is set (i.e., ss=4 if the other bits are not set), the third and fourth portions of the volume block is omitted. If the fourth bit from the right is set (i.e., ss=8 if the other bits are not set), the statistics block is omitted.

The digit d, which represents a number from 0 through 7, can be used to obtain extra output at every hydrodynamic time step. The number is treated as a three-bit binary number. If no bits are set (i.e., the number is 0), the standard output at the requested frequency using the maximum time step is obtained (see words 5 and 6 of this card). If the number is nonzero, output is obtained at each successful time step; and the bits indicate which output is obtained. If the first bit from the right is set (i.e., d=1 if the other bits are not set), major edits are obtained every successful time step. If the second bit from the right is set (i.e., d=2 if the other bits are not set), minor edits are obtained every successful time step. If the third bit from the right is set (i.e., d=4 if the other bits are not set), plot records are written every successful time step. These options should be used carefully, since considerable output can be generated.

The digits tt, that represent a number from 0 through 31, are used to control the time step. The number is treated as a four-bit binary number. The effect of no bits being set, i.e., 0 being entered, and the effect of each bit are first described followed by the recommended combination of bits

If no bits are set (i.e., the number is 0), no error estimate time step control is used, and the maximum time step is attempted for both hydrodynamic and heat structure advancement. The hydrodynamic time step, however, is reduced to the material Courant limit and further to the minimum time step for causes such as water property failures. If the first bit from the right is set (i.e., tt=1 if no other bits are set), the hydrodynamics advancement, in addition to the time step control when no bits are set, uses a mass error analysis to control the time step between the minimum and maximum time step. If the second bit from the right is set (i.e., tt=2 if the other bits are not set), the heat conduction/transfer time step is the same as the hydrodynamic time step; if the second bit from the right is not set, the heat conduction/transfer time step uses the maximum time step. If the third bit from the right is set (i.e., tt=4 if the other bits are not set), the heat conduction/transfer and hydrodynamics are coupled implicitly; if the third bit from the right is not set, the heat conduction/transfer and hydrodynamic advancements are done separately and the information between the models is coupled explicitly. If the fourth bit from the right is set (i.e., tt=8 if the other bits are not set), the nearly-implicit scheme is used to advance the hydrodynamics; if the fourth bit from the right is not set, the semi-implicit scheme is used to advance the hydrodynamics. If the fifth bit from the right is set (i.e., tt=16 if the other bits are not set), the test for convergence of a steady-state calculation is not made; if the fifth bit from the right is not set, the test for convergence of a steady-state calculation is made.

We recommend not using tt equal to 0 except for special testing situations. The use of tt equal to 1 is possible if the maximum time step is kept sufficiently small to ensure that the explicit connection between the heat conduction/transfer and hydrodynamics calculations remains stable. If there is any doubt, use tt equal to or greater than 3 (sets first bit and second bit). Using tt equal to 3 or 11 specifies the semi-implicit or the nearly implicit advancement scheme, respectively, with both schemes using time step control, the heat conduction and hydrodynamics use the same time step, and the heat conduction/transfer and hydrodynamics are advanced separately. Using tt equal to 7 or 15 specifies the same features as tt equal to 3 or 11 and, in addition, specifies the implicit advancement of the heat conduction/transfer with the hydrodynamics. We recommend the nearly implicit scheme during a steady-state and/or self-initialization case problem where the time step is limited by the material Courant limit. The nearly implicit scheme can also be used during slower phases of a transient problem, though we advise the user that the answers may change somewhat from the semi-implicit scheme answers (depending on the time step size). (The nearly implicit advancement scheme is still under development; most of the verification and assessment for the code has been done with the semi-implicit advancement scheme.) We did not recommend use of the implicit coupling of the heat conduction/transfer and hydrodynamics in prior versions since the implicit coupling was only partially implemented. With the implicit coupling now complete, we encourage the use of tt equal to 7 or 15. When using the implicit coupling, the heat conduction time step must be the same as the hydrodynamic time step. This requirement is currently not enforced by the coding. In steady-state calculations, setting the fifth bit (adding 16) for the early part of the run can ensure the calculation runs to a user-specified time; then, setting the fifth bit off can allow the steady-state convergence to test control the termination of the problem.

W5(I) Minor edit and plot frequency. This is the number of maximum or requested time advances per minor edit and write of plot information.

W6(I) Major edit frequency. This is the number of requested time advances per major edit.

W7(I) Restart frequency. This is the number of requested time advances per write of restart information.

A4 CARDS 301 THROUGH 399, MINOR EDIT REQUESTS

These cards are optional for NEW and RESTART problems, are required for a REEDIT problem, and are not allowed for PLOT and STRIP problems. If these cards are not present, no minor edits are printed. If these cards are present, minor edits are generated, and the order of the printed quantities is given by the card number of the request card. One request is entered per card, and the card numbers need not be consecutive. For RESTART problems, if these cards are entered, all the cards from the previous problem are deleted.

W1(A) Variable code (alphanumeric).

W2(I) Parameter (numeric).

Words 1 and 2 form the variable request code pair. The quantities that can be edited and the input required are listed below. For convenience, quantities that can be used in plotting requests, in trip specifications, as search variables in tables, and as operands in control statements are listed. Units for the quantities are also given. Interactive input variables described in Section A6 can be used in batch or interactive jobs in the same manner as the variables listed below. The parameter for interactive input variables is 1000000000. Quantities compared in variable trips must have the same units, and input to tables specified by variable request codes must have the specified units. The quantities are listed in alphabetical order within each section.

The underlined quantities without an asterisk in Section A4.1 through Section A4.8 are always written to the restart-plot file. Underlined quantities followed by an asterisk have only some of the quantities written to the restart-plot file and the text will indicate which quantities are written. The quantities that are not underlined or some of the quantities underlined and followed with an asterisk are written to the restart-plot file only if requested on a 2080xxxx card as described in Section A4.9.

A4.1 General Quantities

Code	Quantity
COUNT	The current attempted advancement count number. The parameter is 0.
CPUTIME	The current CPU time for this problem (s). The parameter is zero.
DT	The current time step (s). The parameter is 0.
DTCRNT	The current Courant time step (s). The parameter is 0.
EMASS	Estimate of mass error in all the systems (kg, lb). The parameter is zero.
ERRMAX	The current estimate of the truncation mass error fraction. The parameter is 0.
NULL	Specifies null field. Allowed only on trip cards. The parameter is zero.
SYSTMS	Total mass of steam, water, and noncondensable in system n (kg, lb). Parameter is system number n.

STDTRN Steady state/transient flag. The parameter is 0. For steady state, the value is 0.0. For transient, the value is 1.0.

SYSMER Estimate of mass error in system n (kg, lb). Parameter is system number n.

TESTDA An array testda, of twenty quantities, (real testda(20)) has been defined for the convenience of program developers. This entry with a parameter ranging from 1 through 20 selects testda(parameter). The testda array is initially set to zero, and programming must be inserted to set testda values. The usual purpose of this capability is to allow a simple method for debug information to be printed in minor edits or to be plotted.

TIME Time (s). The parameter is zero. This request cannot be used for minor edit requests.

TIMEOF Time of trip occurring (s). The parameter is the trip number. This request is allowed only on trip cards.

TMASS Total mass of water, steam, and noncondensables in all the systems (kg, lb). The parameter is zero.

A4.2 Component Quantities

The quantities listed below are unique to certain components; for example, a pump velocity can only be requested for a pump component. The parameter is the component number, i.e., the three-digit number ccc used in the input cards.

Code	Quantity
ACPGTG	Accumulator vapor specific heat, C_p, at vapor temperature (J/kg·K, Btu/lb•°F).
ACPNIT	Accumulator noncondensable specific heat, C_p, at vapor temperature (J/kg•K, Btu/lb•°F).
ACQTANK	Total energy transport to the gas by heat and mass transfer in the accumulator (W, Btu/s)
ACRHON	Accumulator noncondensable density (kg/m^3, lb/ft^3).
ACTTANK	Mean accumulator tank wall metal temperature (K, °F).
ACVDM	Gas volume in the accumulator tank, standpipe, and surge line (m^3, ft^3).
ACVGTG	Accumulator vapor specific heat, C_v, at vapor temperature (J/kg•K, Btu/lb•·°F).
ACVLIQ	Liquid volume in the accumulator tank, standipipe, and surge line (m^3, ft^3).
AHFGTF	Accumulator heat of vaporization at liquid temperature (J/kg, Btu/lb).
AHFGTG	Accumulator heat of vaporization at vapor temperature (m^3/kg, ft^3/lb).

AHFTG Accumulator liquid enthalpy at vapor temperature (J/kg, Btu/lb).

AHGTF Accumulator vapor enthalpy at liquid temperature (J/kg, Btu/lb).

AVISCN Accumulator noncondensable viscosity (kg/m•s, lb/ft•s).

BETAV Accumulator steam saturation coefficient of expansion (K^{-1}, $^oF^{-1}$).

CDIM GE mechanistic dryer critical inlet moisture quality.

DIM GE mechanistic dryer inlet moisture quality.

DMGDT Accumulator/time rate of change in dome vapor mass (kg/s, lb/s).

GDRY GE mechanistic separator capacity factor.

OMEGA Inertial valve disk angular velocity (rad/s, rev/min).

PMPHEAD Pump head in the pump component (Pa, $lb_{f/}$ in^2).

PMPMT Pump motor torque (N•m, lb $_f$•ft).

PMPNRT Calculated pump inertia (kg•×m^2, lb•ft^2).

PMPTRQ Pump torque in the pump component (N•m, lb $_f$•ft).

PMPVEL Pump velocity in the pump component (rad/s, rev/min).

THETA Inertial valve disk angular position (deg).

TUREFF The efficiency of the turbine component.

TURPOW The power developed in the turbine component (W, Btu/s).

TURTRQ The torque developed in the turbine component (N•m, lb_f•ft).

TURVEL The rotational velocity of the turbine component (rad/s, rev/min).PMPMTPumpPump motor torque (N•m, lb_f•ft).

VLVAREA This is the ratio of the current valve physical area to the junction area. The junction area is the fully open valve physical area for the smooth area option and the minimum of the two connecting volumes for the abrupt area change.

VLVSTEM This is the ratio of the current valve stem position to the fully open valve stem position for the motor and servo valves when the normalized stem position option is used. For the motor and servo valves when the normalized area option is used and for all the other valves, this is the ratio of the current valve physical area to the fully open valve physical area.

XCO GE mechanistic separator liquid carryover quality.

XCU GE mechanistic separator vapor carryunder quality.

XI GE mechanistic separator inlet quality.

A4.3 Volume Quantities

For most of the following variable codes, the parameter is the volume number, i.e., the nine-digit number cccnn0000 printed in the major edit. The parameter is ccc010000 for a single volume; ccc010000 for a time-dependent volume; cccnn0000 for a volume in a pipe component (0 < nn < 100); ccc010000 for the volume in a branch, separator, jetmixer, turbine, or ECC mixer component; ccc010000 for the volume in a pump component; and ccc010000 for the volume in an accumulator component. Some of the quantities are associated with the coordinate directions in the volume, and these quantities are computed for each coordinate direction in use. The parameter for the coordinate direction-related quantities is the volume number plus F, where F is described below. The quantities requiring the volume number plus F are so identified.

Every volume has at least one coordinate direction, and some volumes may have up to three orthogonal coordinate directions. Each coordinate has an inlet face and an outlet face. Faces are numbered 1 through 6, where faces 1 and 2 are the inlet and outlet faces associated with coordinate 1 (or x), respectively, faces 3 and 4 are inlet and outlet faces associated with coordinate 2 (or y), and faces 5 and 6 are inlet and outlet faces associated with coordinate 3 (or z). All volumes use coordinate 1. The quantity F to be added to the volume number to form the parameter used with coordinate direction related quantities is 0 or the face number. When F is 0 (i.e., just the volume number), 1, or 2, the volume velocity is for coordinate 1. When F is 3 or 4, the volume velocity is for coordinate 2, and when F is 5 or 6, the volume velocity is for coordinate 3. For the underlined quantities followed by an asterisk in the list below, the coordinate-dependent quantities for coordinate 1 are automatically written to the restart-plot records using the parameter with F equal to 0. The other coordinate-dependent quantities can be written to the plot records using the 208 card series. Input checks are made to ensure the parameter specifies a volume coordinate direction that is in use.

Code	Quantity
AVOL	Area of the volume (m^2, ft^2); the parameter is the volume number plus F.
BETAFF	Liquid isobaric coefficient of the thermal expansion, β_f, bulk conditions (K^{-1}, $^oF^{-1}$).
BETAGG	Vapor isobaric coefficient of the thermal expansion, β_g, bulk conditions (K^{-1}, $^oF^{-1}$).
<u>BORON</u>	Boron density (kg/m^3, lb/ft^3).
CSUBPF	Liquid specific heat, C_{pf}, bulk conditions (J/kg•K, Btu/lb•^{o}F).

CSUBPG Vapor specific heat, C_{pg}, bulk conditions (J/kg•K, Btu/lb•^{o}F).

DRFDP Partial derivative of ρ_f with respect to pressure (s^2/m^2, s^2/ft^2).

DRFDUF Partial derivative of ρ_f with respect to U_f (kg•s^2/m^5, lb•s^2/ft^5).

DRGDP Partial derivative of ρ_g with respect to pressure (s^2/m^2, s^2/ft^2).

DRGDUG Partial derivative of ρ_g with respect to U_g (kg•s^2/m^5, lb•s^2/ft^5).

DRGDXA Partial derivative of ρ_g with respect to X_n (kg/m^3, lb/ft^3).

DSNDDP Steam specific enthalpy at bulk conditions using partial pressure of steam (J/kg, Btu/lb).

DTDP Partial derivative of T^s with respect to pressure (K/Pa, in^2•$^{o}F/lb_f$).

DTDUG Partial derivative of T^s with respect to U_g (s^2•K/m^2, s^2•$^{o}F/ft^2$).

DTDXA Partial derivative of T^s with respect to X_n (K, ^{o}F).

DTFDP Partial derivative of T_f with respect to pressure (K/Pa, in^2•$^{o}F/lb_f$).

DTFDUF Partial derivative of T_f with respect to U_f (s^2•K/m^2, s^2•$^{o}F/ft^2$).

DTGDP Partial derivative of T_g with respect to pressure (K/Pa, in^2•$^{o}F/lb_f$).

DTGDUG Partial derivative of T_g with respect to U_g (s^2•K/m^2, s^2•$^{o}F/ft^2$).

DTGDXA Partial derivative of T_g with respect to X_n (K, ^{o}F).

FLOREG* Flow regime number; the parameter is the volume number plus F. A chart showing the meaning of each number is shown in Section 2 of this volume of the manual.

FWALF Liquid wall frictional drag coefficient (kg/m^3•s, lb/ft^3•s); the parameter is the volume number plus F.

FWALG Vapor wall frictional drag coefficient (kg/m^3•s, lb/ft^3•s); the parameter is the volume number plus F.

GAMMAC Condensation rate near the wall per unit volume (kg/m^3•s, lb/ft^3•s).

GAMMAI Vapor generation rate in the bulk per unit volume (kg/m^3•s, lb/ft^3•s).

GAMMAW — Vapor generation rate near the wall per unit volume (kg/m^3•s, lb/ft^3•s).

HIF — Liquid side interfacial heat transfer coefficient per unit volume (W/m^3•K, Btu/s•ft^3•^{o}F).

HIG — Vapor side interfacial heat transfer coefficient per unit volume (W/m^3•K, Btu/s•ft^3•^{o}F).

HVMIX — Enthalpy of the liquid and vapor (J/kg, Btu/lb).

P — Volume pressure (Pa, lb$_f$/in^2).

PECLTV — Peclet number.

PPS — Steam partial pressure (Pa, lb$_f$/in^2).

Q — Total volume heat source from the wall and direct moderatorheating to liquid and vapor (W, Btu/s). This variable request is the same as TOT.HT.INP. in the major edits.

QUALA — Volume noncondensable mass fraction.

QUALE — Volume equilibrium quality. The quality uses phasic enthalpies, with the mixture enthalpy calculated using the flow quality.

QUALS — Volume static quality.

QWG — Volume heat source from the wall and direct moderator heating to vapor (W, Btu/s). This variable request is the same as VAP.HT.INP. in the major edits.

RHO — Total density (kg/m^3, lb/ft^3).

RHOF — Liquid density (kg/m^3, lb/ft^3).

RHOG — Vapor density (kg/m^3, lb/ft^3).

RHOM — Total density for the mass error check (kg/m^3, lb/ft^3).

SATHF — Liquid specific enthalpy at saturation conditions using partial pressure of steam (J/kg, Btu/lb).

SATHG — Steam specific enthalpy at saturation conditions using partial pressure of steam (J/kg, Btu/lb).

SATTEMP — Volume saturation temperature based on the partial pressure of steam (K, ^{o}F).

SIGMA — Surface tension (J/m^2, Btu/ft^2).

SOUNDE Volume sonic velocity (m/s, ft/s).

TEMPF Volume liquid temperature (K, ^{o}F).

TEMPG Volume vapor temperature (K, ^{o}F).

THCONF Liquid thermal conductivity (W/m•K, Btu/s•ft•^{o}F).

THCONG Vapor thermal conductivity (W/m•K, Btu/s•ft•^{o}F).

TIENGV Total internal energy (of both phases and noncondensables) in volume (J, Btu).

TMASSV Total mass (includes both phases and noncondensables) in volume (kg, lb).

TSATT Saturation temperature corresponding to total pressure (K, ^{o}F).

UF Liquid specific internal energy (J/kg, Btu/lb).

UG Vapor specific internal energy (J/kg, Btu/lb).

VAPGEN Total volume vapor generation rate per unit volume ($kg/m^3 \cdot s$, $lb/ft^3 \cdot s$).

VELF* Volume oriented liquid velocity (m/s, ft/s); the parameter is the volume number plus F.

VELG* Volume oriented vapor velocity (m/s, ft/s); the parameter is the volume number plus F.

VISCF Liquid viscosity (kg/m•s, lb/ft•s).

VISCG Vapor viscosity (kg/m•s, lb/ft•s).

VOIDF Volume liquid fraction.

VOIDG Volume vapor fraction (void fraction).

VOIDLA Void above the level.

VOIDLB Void below the level.

VOLLEV Location of the level inside the volume (m, ft).

VVOL Volume of the volume (m^3, ft^3).

A4.4 Junction Quantities

For the following variable request codes, the parameter is the junction number, i.e., the nine-digit number cccnn0000 printed in the major edit. The parameter is ccc000000 for a single junction; ccc000000 for a time-dependent junction; cccmm0000 for a junction in a pipe component (0 < mm < 99); cccmm0000 for a junction in a branch, separator, jetmixer, turbine, or ECC mixer component (0 < mm < 9); ccc000000 for a valve junction; ccc010000 for the inlet junction in a pump component; ccc020000 for the outlet junction in a pump component; ccciinn00 for a junction in the multiple-junction component; and ccc010000 for the junction in an accumulator component.

Code	Quantity
C0J	Junction distribution coefficient. The 0 in C0J is a zero and not an upper case letter O.
FIJ	Interphase friction ($N \bullet s^2/m^5$, $lb_f \bullet s^2/ft^5$). This is the variable C_i in Volume I in this manual.
FLENTH	Total enthalpy flow in junction (includes both phases and noncondensables) (J/s, Btu/s).
FLORGJ	Junction flow regime number. A chart showing the meaning of each number is shown in Section 2 of this volume of the manual.
FORMFJ	Liquid form loss factor (dimensionless).
FORMGJ	Vapor form loss factor (dimensionless).
IREGJ	Vertical bubbly/slug flow junction flow regime number. A chart showing the meaning of each number is shown in Section 2 of this volume of the manual.
MFLOWJ	Combined liquid and vapor flow rate (kg/s, lb/s).
QUALAJ	Junction noncondensable mass fraction.
RHOFJ	Junction liquid density (kg/m^3, lb/ft^3).
RHOGJ	Junction vapor density (kg/m^3, lb/ft^3).
SONICJ	Junction sound speed (m/s, ft/s).
UFJ	Junction liquid specific internal energy (J/kg, Btu/lb).
UGJ	Junction vapor specific internal energy (J/kg, Btu/lb).
VELFJ	Junction liquid velocity (m/s, ft/s).
VELGJ	Junction vapor velocity (m/s, ft/s).
VGJJ	Vapor drift velocity (m/s, ft/s).
VOIDFJ	Junction liquid fraction.
VOIDGJ	Junction vapor fraction (void fraction).

VOIDJ Junction vapor fraction (void fraction) used in the interphase drag.

XEJ Junction equilibrium quality.

A4.5 Heat Structure Quantities

For the request code, HTVAT, the parameter is the seven-digit heat structure number cccg0nn. For the remaining codes, the parameter is the seven-digit heat structure number cccg0nn with a two-digit number appended. For codes other than HTTEMP and HTVAT, the appended number is 00 for the left boundary and 01 for the right boundary. For HTTEMP, the appended number is the mesh point number. For HTVAT, omit the two appended digits and use only the seven digit number. Only the left and right surface temperatures are written by default in plot records on the RSTPLT file, and, thus, plot requests in plot-type problems and strip requests are limited to those temperatures unless the interior temperatures are forced to the RSTPLT file through 2080xxxx cards.

Code	Quantity
HTCHF	Critical heat flux (W/m^2, $Btu/s{\bullet}ft^2$).
HTGAMW	Wall vapor generation rate per unit volume ($kg/m^3{\bullet}s$, $lb/ft^3{\bullet}s$). The parameter is the heat structure geometry number cccg0nn with a two-digit number appended (00 for the left boundary, and 01 for the right boundary).
HTHTC	Heat transfer coefficient ($W/m^2{\bullet}K$, $Btu/s\text{-}ft^2{\bullet}{}^oF$).
HTMODE	Boundary heat transfer mode number (unitless). The mode number indicates which heat transfer regime is currently in effect. The parameter is the seven-digit heat structure geometry number, cccg0nn, with a two-digit number appended. The two-digit appended number, 00, specifies the left boundary, and 01 specifies the right boundary. This same quantity is valid for the reflood heat structures. A chart showing the meaning of each number is shown in Section 3.2 of this volume of the manual.
HTRG	Heat flux to vapor phase (W/m^2, $Btu/s{\bullet}ft^2$). The parameter is the heat structure geometry number, cccg0nn, with a two-digit number appended (00 for the left boundary, and 01 for the right boundary).
HTRNR	Heat flux (W/m^2, $Btu/s{\bullet}ft^2$).
HTTEMP*	Mesh point temperature (K, ${}^oF$). The parameter is the heat structure geometry number cccg0nn with a two-digit number appended (mesh point number). The surface temperatures are written to the plot record but interior mesh point temperatures must be requested through the 2080xxxx cards.
HTVAT	Volume averaged temperature in the heat structure (K, ${}^oF$)

PECL	Liquid Peclet number for the heat structures. The parameter is the heat structure geometry number cccg0nn with a two-digit number appended (00 for the left boundary, and 01 for the right boundary).
STANT	Stanton number. The parameter is the heat structure geometry number cccg0nn with a two-digit number appended (00 for the left boundary, and 01 for the right boundary).

A4.6 Reflood-Related Quantities

For the following variable codes, the parameter is the heat structure geometry number, i.e., the seven-digit number cccg0nn printed in the major edit.

Code	Quantity
QFCHFN	Critical heat flux (W/m^2, Btu/s•ft^2).
QFHTCN	Critical heat transfer coefficient (W/m^2•K, Btu/s.•ft^2•^{o}F).
TCHFQF	Temperature corresponding to QFCHFN (K, ^{o}F).
TREWET	Rewet temperature (K, ^{o}F).
ZTRWT	Position of CHF point (m, ft).

A4.7 Reactor Kinetic Quantities

The parameter is zero for the following reactor kinetic quantities. The following list is for point kinetics variables.

Code	Quantity
RKFIPOW	Reactor power from fission (W).
RKGAPOW	Reactor power from fission product decay (W).
RKREAC	Reactivity (dollars).
RKRECPER	Reciprocal period (s^{-1}).
RKTPOW	Total reactor power, i.e., sum of fission and fission product decay power (W).

A4.8 Control System Quantities

The parameter is the control component number, i.e., the three-digit number, ccc, or the four-digit number, cccc, used in the input cards.

CNTRLVAR Control component number. These quantities are assumed dimensionless except for a SHAFT component.

A4.9 Cards 2080xxxx, Expanded Plot Variables

The underlined variables listed above are always available for plotting. The variables that are not underlined and some of the underlined variables followed by an asterisk are not written to the restart-plot file and are thus unavailable for plotting unless the user enters the desired variables on 2080xxxx cards. The format of these cards is given below. They are only required for the additional variables that the user wants to have written on the restart-plot file. The user can specify that between 1 and 9999 of these variables be written to the restart-plot file.

The field xxxx need not be consecutive.

W1(A) Variable request code. See the previous sections for valid request codes.

W2(I) Parameter. Enter the parameter associated with the variable request code.

A5 CARDS 400 THROUGH 799 OR 20600000 THROUGH 20620000, TRIP INPUT DATA

These cards are optional for NEW and RESTART type problems and are not used for other problem types. Two different card series are available for entering trip data, but only one series type may be used in a problem. Card numbers 401 through 799 allow 199 variable trips and 199 logical trips. Card numbers 20600010 through 20620000 allow 1000 variable trips and 1000 logical trips.

A5.1 Card 400, Trips Cancellation Card

This card is allowed only for RESTART problems. The card causes all trips in the problem being restarted to be deleted. Any desired trips must be reentered.

W1(A) Discard. Any other entry is an error.

A5.2 Card 20600000, Trip Card Series Type

This card, if omitted, selects card numbers 401 through 599 for variable trips and 601 through 799 for logical trips. For this case, the trip numbers are equal to the card numbers.

If this card is entered, card numbers 206nnnn0 are used for entering trip data, and nnnn is the trip number. Trip numbers (nnnn) 1 to 1000 are variable trips, and 1001 to 2000 are logical trips. Trip numbers do not have to be consecutive.

W1(A) Expanded. Any other entry is an error.

A5.3 Cards 401 through 599 or 20600010 through 20610000, Variable Trip Cards

Each card defines a logical statement or trip condition concerned with the quantities being advanced in time. A trip is false or not set if the trip condition is not met, and true if it is met. On restart, new trips can be introduced, old trips can be deleted, and a new trip with the same number as an old trip replaces the old trip.

The variable codes and parameters are the same as described for minor edits, Section A4 NULL is allowed for the right side when only a comparison to the constant is desired. The variable code TIMEOF, with the parameter set to the trip number, indicates the time at which the trip was last set. If the trip goes false, TIMEOF is set to -1.0.

W1(A) Variable code. On RESTART problems, this word can also contain DISCARD or RESET. DISCARD deletes the trip; RESET sets the trip to false. If DISCARD or RESET are entered, no further words are entered on the card.

W2(I) Parameter.

W3(A) Relationship. This may be either EQ, NE, GT, GE, LT, or LE, where the symbols have the standard FORTRAN meaning. Do not enter periods as part of the designator. For example, use GE rather than .GE. to specify *greater than* or *equal to*.

W4(A) Variable code.

W5(I) Parameter.

W6(R) Additive constant.

W7(A) Latch indicator. If L, the trip once set true remains true, even if the condition later is not met. If N, the trip is tested each time advancement.

W8(R) Timeof quantity (s). This word is optional. If it is not entered, the trip is initialized as false and the associated TIMEOF quantity is set to -1.0. If -1.0 is entered, the trip is initialized as false. If zero or a positive number is entered for TIMEOF, the trip is initialized as true. TIMEOF must not be greater than zero for NEW problems and must not be greater than the time of restart for RESTART problems.

The logical statement is “Does the quantity given by Words 1 and 2 have the relationship given by Word 3 with the quantity given by Words 4 and 5 plus Word 6?” If the relationship is false, the trip is false or not set. If the relationship is true, the trip is true or set. The TIMEOF variable is -1.0 if the trip is false. If the trip is true, this variable is the time the trip was last set true. A latched trip is never reset, so the trip time never changes once it changes from -1.0. For the nonlatched trips, the trip time when set remains constant until the trip condition becomes false and then the trip time is -1.0 again. If the trip condition becomes true again, the process is repeated. For trips such as a time test, L should be used to eliminate repeated testing, although no error or difference in results will occur if N is used.

A5.4 Cards 601 through 799 or 20610010 through 20620000, Logical Trip Cards

If these cards are entered, at least one of the variable trip cards must have been entered. Each card defines a logical relationship with the trips defined on these cards or on the variable trip cards. (For a more detailed description of this input, see Section 4.1.4.)

W1(I) Trip number. The absolute value of this number must be one of the trip numbers defined by the variable or logical trip cards. A negative trip number indicates that the complement of the trip is to be used in the test.

W2(A) Operator. The operator may be AND, OR, or XOR. For RESTART problems, this quantity may also contain DISCARD or RESET. DISCARD deletes the trip and RESET sets the trip to false. If DISCARD or RESET are entered, no further words are entered on the card and Word 1 (W1) may be zero.

W3(I) Trip number. This is similar to Word 1 (W1).

W4(A) Latch indicator. If L, the trip when set remains set. If N, the trip is tested each time advancement.

W5(R) Timeof quantity (s). This word is optional. If not entered, the trip is initialized as false, and the associated TIMEOF quantity is set to -1.0. If -1.0 is entered, the trip is initialized as false. If zero or a positive number is entered for TIMEOF, the trip is initialized as true.

TIMEOF must not be greater than zero for NEW problems and must not be greater than the time of restart for RESTART problems.

The trip condition is given by the result of the following logical expression:

CONDITION OF TRIP IN W1 OPERATOR CONDITION OF TRIP IN W3.

A5.5 Card 600, Trip Stop Advancement Card

This card can be entered in NEW and RESTART problems. One or two trip numbers may be entered. If either of the indicated trips are true, the problem advancement is terminated. These trips are tested only at the end of a requested advancement. If the trips can cycle true and false, they should be latched-type trips to ensure being true at the test time.

W1(I) Trip number.

W2(I) Trip number. A second trip number need not be entered.

A6 CARDS 801 THROUGH 999, INTERACTIVE INPUT DATA

An interactive and color display capability exists when the code is interfaced with Nuclear Plant Analyzer (NPA) software. This capability allows a user to view selected results on a color graphics terminal and to modify user-defined input quantities. A user can view RELAP5/MOD3.2 output in a format that enhances understanding of the transient phenomena and enter commands during the simulation. This input, coupled with trip and control system capability, allows a user to initiate operator-like actions, such as opening/closing valves, starting/stopping/changing speed on pumps, and changing operating power settings.

These data may be entered for either batch or interactive jobs. These cards may be used in a NEW or RESTART job; in a restart job, they add to or replace data in the restarted problem.

These cards define variables that may be changed during execution by data input from a computer terminal if the job is being run interactively. The card input defines input variable names and initial values. These variables are completely independent from the Fortran variable names used in the RELAP5 coding, even if they are spelled the same. These user-defined variables can appear wherever variables listed in Section A4 can be used. Thus, the user-defined variables can be used in trips, control variable statements, search arguments for some tables, edited in minor edits, and plotted. With appropriate input, an interactive user can effect changes similar to those made by a reactor operator, such as opening/closing/repositioning valves or setting new operating points in controllers. When entering these user-defined variables, the variable name is the alphanumeric part of the variable request code, and 1000000000 is the numeric part.

W1(A) Variable name. Enter the variable name or DELETE in a RESTART job to delete the variable.

W2(R) Initial value. This is not needed if DELETE is entered in Word 1.

In interactive execution, the initial value is used until changed by a terminal entry. The value can be changed at any time and as often as needed. One or more variables can be changed by entering the variable name and value pairs on the computer terminal. An example is VLV1=0 VLV2,1 VLV3,0, POWER=3050.+6, where VLV1, VLV2, VLV3, and POWER are user-defined variable names. The format is identical to data input on cards. An equal sign is treated as a terminating comma. The values should be floating-point quantities, but integers are converted to floating point values. The NPA interface also allows other more convenient methods for entering new values during the simulation.

W3(R) Conversion factor. Word 2 or any terminal-entered replacement value is entered in user-defined units. These quantities should be converted to SI units if they are to be involved in comparisons or computations with quantities advanced in time. User units can be used only if these input interactive variables are used with control variables defined in compatible units. This word, if nonzero, is the conversion factor. If this word is positive, the conversion is V(converted) = V(input)*W3. If negative, V(converted) = V(input)/1.8 - W3. For temperature conversion from ^{o}F to K, Word 3 should be -255.3722222. If this word is missing, the conversion factor defaults to 1.0. If this word is zero, the next two words must contain a variable request code, and the conversion factor appropriate for this quantity is supplied by the code. If SI units are in use, the supplied conversion factor is 1.0. If British units are in use, the appropriate conversion factor is supplied.

A7 CARDS CCCXXNN, HYDRODYNAMIC COMPONENTS

These cards are required for NEW type problems and may be entered for RESTART problems. Hydrodynamic systems are described in a NEW problem. In a RESTART problem, the hydrodynamic systems may be modified by deleting, adding, or replacing components. The resultant problem must describe at least two volumes and one junction. The hydrodynamic card numbers are divided into fields, where ccc is the component number (the component numbers need not be consecutive), xx is the card type, and nn is the card number within type. When a range is indicated, the numbers need not be consecutive.

A7.1 Card ccc0000, Component Name and Type

This card is required for each component.

W1(A) Component name. Use a name descriptive of the component's use in system. A limit of 10 characters is allowed for CDC-7600 computers, and a limit of 8 characters is allowed for most other computers, e.g., CRAY, Cyber-205, and IBM computers.

W2(A) Component type. Enter one of the following component types, SNGLVOL, TMDPVOL, SNGLJUN, TMDPJUN, PIPE, ANNULUS, BRANCH, SEPARATR, JETMIXER, TURBINE, ECCMIX, VALVE, PUMP, MTPLJUN, ACCUM, or the command DELETE. The command DELETE is allowed only in RESTART problems, and the component number must be an existing component at the time of restart. The DELETE command deletes the component.

The remaining cards for each component depend on the type of component.

A7.2 Single-Volume Component

A single-volume component is indicated by SNGLVOL on Card ccc0000. The junction connection code determines the placement of the volume within the system. More than one junction may be connected to an inlet or outlet. If an end has no junctions, that end is considered a closed end. Normally, only a branch has more than one junction connected to a volume end. For major edits, minor edits, and plot variables, the volume in the single volume component is numbered as ccc010000.

A7.2.1 Cards ccc0101 through ccc0109, Single Volume X-Coordinate Volume Data

This card (or cards) is required for a single volume component. The nine words can be entered on one or more cards, and the card numbers need not be consecutive.

W1(R) Volume flow area (m^2, ft^2).

W2(R) Length of volume (m, ft).

W3(R) Volume of volume (m^3, ft^3). The program requires that the volume equals the volume flow area times the length (W3=W1*W2). At least two of the three quantities, W1, W2, and W3, must be nonzero. If one of the quantities is zero, it will be computed from the other two. If none of the words are zero, the volume must equal the area times the length within a relative error of 0.000001.

W4(R) Azimuthal angle (degrees). The absolute value of this angle must be $\leq$360 degrees and is defined as a positional quantity. This quantity is not used in the calculation but is specified for possible automated drawing of nodalization diagrams.

W5(R) Inclination angle (degrees). The absolute value of this angle must be $\leq$90 degrees. The angle 0 degrees is horizontal; and positive angles have an upward inclination, i.e., the inlet is at the lowest elevation. This angle is used in the interphase drag calculation.

W6(R) Elevation change (m, ft). A positive value is an increase in elevation. The absolute value of this quantity must be less than or equal to the volume length. If the vertical angle orientation is zero, this quantity must be zero. If the vertical angle is nonzero, this quantity must also be nonzero and have the same sign. When the absolute value of the elevation angle determined by the ratio of the elevation change (this word 6) and the volume length (word 2) is less than or equal to 45 degrees, the horizontal flow regime map is used. When the ratio is greater than 45 degrees, the vertical flow regime map is used.

W7(R) Wall roughness (m, ft).

W8(R) Hydraulic diameter (m, ft). This should be computed from 4.0*(volume flow area)/(wetted perimeter). If zero, the hydraulic diameter is computed from 2.0*(volume flow area/ π)**0.5. A check is made to ensure the pipe roughness is less than half the hydraulic diameter. See word 1 for volume flow area.

W9(I) Volume control flags. This word has the packed format tlpvbfe. It is not necessary to input leading zeros. Volume flags consist of scaler oriented and coordinate direction oriented flags. Only one value for a scaler oriented flag is entered per volume but up to three coordinate oriented flags can be entered for a volume, one for each coordinate direction. At present, the f flag is the only coordinate direction oriented flag. This word enters the scaler oriented flags and the x-coordinate flag.

The digit t specifies whether the thermal front tracking model is to be used; t=0 specifies that the front tracking model is not to be used for the volume, and t=1 specifies that the front tracking model is to be used for the volume.

The digit l specifies whether the mixture level tracking model is to be used; l=0 specifies that the level model not be used for the volume, and l=1 specifies that the level model be used for the volume.

The digit p specifies whether the water packing scheme is to be used. p=0 specifies that the water packing scheme is to be used for the volume, and p=1 specifies that the water packing scheme is not to be used for the volume. The water packing scheme is recommended when modeling a pressurizer.

The digit v specifies whether the vertical stratification model is to be used. v=0 specifies that the vertical stratification model is to be used for the volume, and v=1 specifies that the vertical stratification model is not to be used for the volume. The vertical stratification model is recommended when modeling a pressurizer.

The digit b specifies the interphase friction that is used. b=0 means that the pipe interphase friction model will be applied, b=1 means that the rod bundle interphase friction model will be applied, and b=2 means that the narrow channel model will be applied.

The digit f specifies whether wall friction is to be computed. f=0 specifies that wall friction effects are to be computed along the x coordinate of the volume, and f=1 specifies that wall friction effects are not to be computed along the x coordinate.

The digit e specifies if nonequilibrium or equilibrium is to be used. e=0 specifies that a nonequilibrium (unequal temperature) calculation is to be used, and e=1 specifies that an equilibrium (equal temperature) calculation is to be used. Equilibrium volumes should not be connected to nonequilibrium volumes. The equilibrium option is provided only for comparison with other codes.

A7.2.2 Cards ccc0181 through ccc0189, Single-Volume Y-Coordinate Volume Data

These cards are optional. These cards are used when the user specifies the y-direction connection with the crossflow model.

W1(R) Area of the volume (m^2).

W2(R) Length of the crossflow volume (m).

W3(R) Roughness.

W4(R) Hydraulic diameter (m).

W5(I) Volume control flags. This word has the general packed format tlpvbfe, but this word is limited to 00000f0 since it only enters the coordinate oriented flags for the y direction.

The digit f specifies whether wall friction is to be computed. f=0 specifies that wall friction effects are to be computed along the y coordinate direction in the volume, and f=1 specifies that wall friction effects are not to be computed along the y coordinate direction.

W6(R) This word is not used. Enter 0.

W7(R) This word is not used. Enter 0.

W8(R) This word is the position change in the z fixed (vertical) direction as the flow passes from the y inlet face to the y outlet face (m, ft). This quantity affects problems if connections are made to the y faces.

A7.2.3 Cards ccc0191 through ccc0199, Single-Volume Z-Coordinate Volume Data

These cards are optional. These cards are used when the user specifies the z-direction connection with the crossflow model.

W1(R) Area of the volume (m^2).

W2(R) Length of the crossflow volume (m).

W3(R) Roughness.

W4(R) Hydraulic diameter (m).

W5(I) Volume control flags. This word has the general packed format tlpvbfe, but this word is limited to 00000f0 since it only enters the coordinate oriented flags for the z direction.

The digit f specifies whether wall friction is to be computed. f=0 specifies that wall friction effects are to be computed along the z coordinate direction in the volume, and f=1 specifies that wall friction effects are not to be computed along the z coordinate direction.

W6(R) This word is not used. Enter 0.

W7(R) This word is not used. Enter 0.

W8(R) This word is the position change in the z fixed (vertical) direction as the flow passes from the z inlet face to the z outlet face (m, ft). This quantity affects problems if connections are made to the z faces.

A7.2.4 Card ccc0131, Additional Laminar Wall Friction Card

This card is optional. If this card is not entered, the default values are 1.0 for the shape factor and 0.0 for the viscosity ratio exponent. Two, four, or six quantities may be entered on the card, and the data not entered are set to default values. A detailed description of this model is presented in Section 3 of Volume I.

W1(R) Shape factor for x-coordinate.

W2(R) Viscosity ratio exponent for x-coordinate.

W3(R) Shape factor for y-coordinate.

W4(R) Viscosity ratio exponent for y-coordinate.

W5(R) Shape factor for z-coordinate.

W6(R) Viscosity ratio exponent for z-coordinate.

A7.2.5 Card ccc0200, Single-Volume Initial Conditions

This card is required for a single volume.

W1(I) Control word. This word has the packed format εbt. It is not necessary to input leading zeros.

The digit ε specifies the fluid. ε =0 is the default fluid, ε =1 specifies water, ε=2 specifies D_2O, and ε =3 specifies H_2. The default fluid is that set for the hydrodynamic system by

Cards 120 through 129 or this control word in another volume in this hydrodynamic system. The fluid type set on Cards 120 through 129 or these control words must be consistent (i.e., not specify different fluids). If Cards120 through 129 are not entered and all control words use the default $\underline{\varepsilon}$ =0, then H_2O is assumed as the fluid.

The digit $\underline{b}$ specifies whether boron is present or not. The digit $\underline{b}$=0 specifies that the volume fluid does not contain boron; $\underline{b}$=1 specifies that a boron concentration in parts of boron per parts of liquid (which may be zero) is being entered after the other required thermodynamic information.

The digit $\underline{t}$ specifies how the following words are to be used to determine the initial thermodynamic state. Entering $\underline{t}$=0 through 3 specifies only one component (steam/water). Entering $\underline{t}$=4 through 6 allows the specification of two components (steam/water and noncondensable gas).

If $\underline{t}$=0, the next four words are interpreted as pressure (Pa, lb_f/in^2), liquid specific internal energy (J/kg, Btu/lb), vapor specific internal energy (J/kg, Btu/lb), and vapor void fraction; these quantities will be interpreted as nonequilibrium or equilibrium conditions depending on the volume control flag. If equilibrium, the static quality is checked; but only the pressure and internal energies are used to define the thermodynamic state.

If $\underline{t}$=1, the next two words are interpreted as temperature (K, ^oF) and quality in equilibrium condition.

If $\underline{t}$=2, the next two words are interpreted as pressure (Pa, lb_f/in^2) and quality in equilibrium condition.

If $\underline{t}$=3, the next two words are interpreted as pressure (Pa, lb_f/in^2) and temperature (K, ^oF) in equilibrium condition.

The following options are used for input of noncondensable states only. In all cases, the criteria used for determining the range of values for quality are

1.0E-9 $\leq$ quality $\leq$ 0.99999999, two phase conditions, and quality < 1.0 E-9 or quality > 0.99999999, single phase. Section 3 of Volume I presents the definitions of quality.

Noncondensable options are as follows:

If $\underline{t}$=4, the next three words are interpreted as pressure (Pa, lb_f/in^2), temperature (K, ^oF), and equilibrium quality. Using this input option with quality 0.0 and $\leq$1.0, saturated noncondensables will result. Also, the temperature is restricted to be less than the saturation temperature at the input pressure. Setting quality to 0.0 is used as a flag that will initialize the volume to all noncondensable (dry noncondensable) with no temperature restrictions. Quality is reset to 1.0 using this dry noncondensable option.

If $\underline{t}$=5, the next three words are interpreted as temperature (K, ^oF), equilibrium quality, and noncondensable quality. Both the equilibrium and noncondensable qualities are restricted to be between 1.0 E-9 and 0.99999999. Little experience has been obtained using this option, and it has not been checked out.

If t=6, the next five words are interpreted as pressure (Pa, lb_f/in^2), liquid specific internal energy (J/kg, Btu/lb), vapor specific internal energy (J/kg, Btu/lb), vapor void fraction, and noncondensable quality. The combinations of vapor void fraction and noncondensable quality must be thermodynamically consistent. If noncondensable quality is set to 0.0, noncondensables are not present and the input processing branches to that type of processing. If noncondensables are present and noncondensable quality is greater than 0.0, then the vapor void fraction must not be 0.0. If the noncondensable quality is set to 1.0 (pure noncondensable), then the vapor void fraction must also be 1.0. When both the vapor void fraction and the noncondensable quality are set to 1.0, the volume temperature is calculated from the noncondensable energy equation using the input vapor specific internal energy.

W2-W7(R) Quantities as described under Word1 (W1). Depending on the control word, two through five quantities may be required. Enter only the minimum number required. If entered, boron concentration follows the last required word for thermodynamic conditions.

A7.3 Time-Dependent Volume Component

This component is indicated by TMDPVOL on card ccc0000. For major edits, minor edits, and plot variables, the volume in the time-dependent volume component is numbered as ccc010000.

A7.3.1 Cards ccc0101 through ccc0109, Time-Dependent Volume Geometry Cards

This card (or cards) is required for a time-dependent volume component. The nine words can be entered on one or more cards, and the card numbers need not be consecutive.

W1(R) Volume flow area (m^2, ft^2).

W2(R) Length of volume (m, ft).

W3(R) Volume of volume (m^3, ft^3). The program requires that the volume equals the volume flow area times the length (W3=W1*W2). At least two of the three quantities, W1, W2, and W3, must be nonzero. If one of the quantities is zero, it will be computed from the other two. If none of the words are zero, the volume must equal the area times the length within a relative error of 0.000001.

W4(R) Azimuthal angle (degrees). The absolute value of this angle must be ≤ 360 degrees. This quantity is not used in the calculation but is specified for possible automated drawing of nodalization diagrams.

W5(R) Inclination angle (degrees). The absolute value of this angle must be ≤ 90 degrees. The angle 0 degrees is horizontal, and positive angles have an upward inclination, i.e., the inlet is at the lowest elevation. This angle is used in the interphase drag calculation.

W6(R) Elevation change (m, ft). A positive value is an increase in elevation. The absolute value of this quantity must be less than or equal to the volume length. If the vertical angle orientation is zero, this quantity must be zero. If the vertical angle is nonzero, this quantity must also be nonzero and have the same sign. As with the other components, this word 6 is compared to the volume length (word 2) to determine if the horizontal or vertical flow regime map is used. This is not important for this component, since the correlations that depend on the flow regime maps are not needed for this component. The volume conditions are prescribed through input cards ccc0201-ccc0299.

W7(R) Wall roughness (m, ft).

W8(R) Hydraulic diameter (m, ft). This should be computed fro 4*(volume flow area)/(wetted perimeter). If zero, the hydraulic diameter is computed from 2.0*(volume flow area/π)**0.5. A check is made to ensure the pipe roughness is less than half the hydraulic diameter. See word 1 for the volume flow area.

W9(I) Volume control flags. This word has the packed format tlpvbfe. It is not necessary to input leading zeros. Volume flags consist of scaler oriented and coordinate direction oriented flags. Only one value for a scaler oriented flag is entered per volume but up to three coordinate oriented flags can be entered for a volume, one for each coordinate direction. At present, the f flag is the only coordinate direction oriented flag. This word enters the scaler oriented flags and the x coordinate flag. The time dependent component uses only the e digit and y and z coordinate data are not read.

The digit t is not used and must be entered as zero (t=0). The thermal stratification model is not used in a time dependent volume.

The digit l is not used and must be entered as zero (l=0). The level tracking model is not used in a time dependent volume.

The digit p is not used and should be input as zero (p=0). The major edit will show p=1.

This digit v is not used and should be input as zero (v=0). The major edit will show v=1.

The digit b specifies the interphase friction that is used. b=0 means that the pipe interphase friction model will be applied, and b=1 means that the rod bundle interphase friction model will be applied. The interphase friction models are not used for time-dependent volumes, so either b=0 or b=1 can be inputted and the output will show the digit entered.

The digit f specifies whether wall friction is to be computed. f=0 specifies that wall friction effects are to be computed for the volume, and f=1 specifies that wall friction effects are not to be computed for the volume. The wall friction model is not used for time-dependent volumes, so either f=0 or f=1 can be inputted and the output will show the digit entered.

The digit e specifies if nonequilibrium or equilibrium is to be used. e=0 specifies that a nonequilibrium (unequal temperature calculation is to be used, and e=1 specifies that an equilibrium (equal temperature) calculation is to be used. Equilibrium volumes should not be connected to nonequilibrium volumes. The equilibrium option is provided only for comparison to other codes. The nonequilibrium and equilibrium options are not used for time-dependent volumes, so either e=0 or e=1 can be used.

A7.3.2 Card ccc0200, Time-Dependent Volume Data Control Word

This card is required for a time-dependent volume.

W1(I) Control word for time-dependent data on ccc02nn cards. This word has the packed format εbt. It is not necessary to input leading zeros.

The digit ε specifies the fluid. ε=0 is the default fluid, ε=1 specifies H_2O, ε=2 specifies D_20, and ε=3 specifies H_2. The default fluid is that set for the hydrodynamic system by Cards 120 through 129 or this control word in another volume in this hydrodynamic system. The fluid type set on Cards 120 through 129 or these control words within the hydrodynamic system must be consistent (i.e., not specify different fluids). If Cards 120 through 129 are not entered and all control words use the default ε=0, then H_2O is assumed as the fluid.

The digit b specifies whether boron is present or not. The digit b=0 specifies that the volume fluid does not contain boron; b=1 specifies that a boron concentration in parts of boron per parts of liquid water (which may be zero) is being entered after the other required thermodynamic information.

The digit t specifies how the words of the time-dependent volume data in Cards ccc0201 through ccc0299 are to be used to determine the initial thermodynamic state. Entering t equal to 0 through 3 specifies one component (steam/water). Entering t equal to 4 through 6 allows the specification of two components (steam/water and noncondensable gas).

With options 4 through 6, Card 110 defining components of the noncondensable gas must be entered and mass fractions of the components are entered on Card ccc0301, if entered, or are taken from the default data on Card 115. Entering t=7 specifies three components, liquid/steam, noncondensable gas, and a molten metal. Option 7 requires Card 110 and Card ccc0301 or Card 115 similarly to options 4 through 6. In addition, option 7 requires Card 111 defining components of the metal. The mass fractions are defined by Card ccc0302 if entered or from Card 116.

If t=0, the second, third, fourth, and fifth words of the time-dependent volume data on Cards ccc0201 through ccc0299 are interpreted as pressure (Pa, lb_f/in^2), liquid specific internal energy (J/kg, Btu/lb), vapor specific internal energy (J/kg, Btu/lb), and vapor void fraction; these quantities will be interpreted as nonequilibrium or equilibrium conditions depending on the volume control flag. If equilibrium, the static quality is checked, but only the pressure and internal energies are used to define the thermodynamic state. Enter only the minimum number of words required. If entered, boron concentration follows the last required word for thermodynamic conditions.

If t=1, the second and third words of the time-dependent volume data on Cards ccc0201 through ccc0299 are interpreted as temperature (K, ^oF) and quality in equilibrium condition. Enter only the minimum number of words required. If entered, boron concentration follows the last required word for thermodynamic conditions.

If t=2, the second and third words of the time-dependent volume data on Cards ccc0201 through ccc0299 are interpreted as pressure (Pa, lb_f/in^2) and quality in equilibrium condition. Enter only the minimum number of words required. If entered, boron concentration follows the last required word for thermodynamic conditions.

If t=3, the second and third words of the time-dependent volume data on Cards ccc0201 through ccc0299 are interpreted as pressure (Pa, lb_f/in^2) and temperature (K, ^oF) in equilibrium conditions. Enter only the minimum number of words required. If entered, boron concentration follows the last required word for thermodynamic conditions.

The following options are used for input of noncondensable states only. In all cases, the criteria used for determining the range of values for quality are

1.0E-9 $\leq$ quality $\leq$ 0.99999999, two-phase conditions, and quality < 1.0E-9 or quality > 0.99999999, single-phase.

Noncondensable options are as follows:

If t=4, the second, third, and fourth words of the time-dependent data on Cards ccc0201 through ccc0299 are interpreted as pressure (Pa, $lb_f/in.^2$), temperature (K, ^oF), and equilibrium quality. Using this input option with quality >0.0 and $\leq$1.0, saturated noncondensables will result. Also, the temperature is restricted to be less than the saturation temperature at the input pressure. Setting quality to 0.0 is used as a flag that will initialize the volume to all noncondensable (dry noncondensable) with no temperature restrictions. Quality is reset to 1.0 using this dry noncondensable option. Enter only the minimum number of words required. If entered, boron concentration follows the last required word for thermodynamic conditions.

If t=5, the second, third, and fourth words of the time-dependent data on Cards ccc0201 through ccc0299 are interpreted as temperature (K, ^oF), equilibrium quality, and noncondensable quality. Both the equilibrium and noncondensable qualities are restricted to be between 1.0E-9 and 0.99999999. Enter only the minimum number of words required. If entered, boron concentration follows the last required word for thermodynamic conditions. Little experience has been obtained using this option, and it has not been checked out.

If t=6, the second, third, fourth, fifth, and sixth words of the time-dependent data on Cards ccc0201 through ccc0299 are interpreted as pressure (Pa, $lb_f/in.^2$), liquid specific internal energy (J/kg, Btu/lb), vapor specific internal energy (J/kg, Btu/lb), vapor void fraction, and noncondensable quality. The combinations of vapor void fraction and noncondensable quality must be thermodynamically consistent. If noncondensable quality is set to 0.0, noncondensables are not present, and the input processing branches to that type of processing. If noncondensables are present (noncondensable quality greater than 0.0), then the vapor void fraction must not be 0.0. If the noncondensable quality is set to 1.0 (pure noncondensable), then the vapor void fraction must also be 1.0. When both the vapor void fraction and the noncondensable quality are set to 1.0, the volume temperature is calculated from the noncondensable energy equation using the input vapor specific internal energy. Enter only the minimum number of words required. If entered, boron concentration follows the last required word for thermodynamic conditions.

If t=7, the next seven words are interpreted as pressure (Pa, lb_f/in^2), liquid-specific internal energy (J/kg, Btu/lb), vapor-specific internal energy (J/kg, Btu/lb), vapor void fraction, noncondensable quality, metal internal energy (J/kg, Btu/lb) and metal void fraction. The sum of the vapor void fraction and the metal void fraction must be greater than or equal to zero and less than or equal to one. The noncondensable quality must be greater than or equal to zero and less than or equal to one. Enter only the minimum number of words required. If entered, boron concentration follows the last required word for thermodynamic conditions.

W2(I) Table trip number. This word is optional. If missing or zero and Word 3 is missing, no trip is used, and the time argument is the advancement time. If nonzero and Word 3 is missing, this number is the trip number, and the time argument is -1.0 if the trip is false, and the advancement time minus the trip time if the trip is true.

W3(A) Alphanumeric part of variable request code. This quantity is optional. If not present, time is the search argument. If present, this word and the next are a variable request code that specifies the search argument for the table lookup and interpolation. If the trip number is zero, the specified argument is used. If the trip number is nonzero, -1.0E+75 is used if the trip is false, and the specified argument is used if the trip is true. TIME can be selected, but note that the trip logic is different than if this word were omitted.

W4(I) Numeric part of variable request code. This is assumed zero if missing.

A7.3.3 Cards ccc0201 through ccc0299, Time-Dependent Volume Data Cards

These cards are required for time-dependent volume components. A set of data is made up of the search variable (e.g., time) followed by the required data indicated by control word 1 in Card ccc0200. The card numbers need not be consecutive, but the value of the search variable in a succeeding set must be equal to or greater than the value in the previous set. One or more sets of data, up to 5000 sets, are allowed. Enter only the minimum number of words required. If entered, boron concentration follows the last required word for thermodynamic conditions. Linear interpolation is used if the search argument lies between the search variable entries. End-point values are used if the argument lies outside the table values. Only one set is needed if constant values are desired, and computer time is reduced when only one set is entered. Step changes can be accommodated by entering the two adjacent sets with the same search variable values or an extremely small difference between them. Given two identical argument values, the set selected will be the closest to the previous argument value. Sets may be entered one or more per card and may be split across cards. The total number of words must be a multiple of the set size.

Inputting time-dependent volume tables where the search variable is a thermodynamic variable from some other component can run into difficulties if the component numbering is such that the time-dependent volume is initialized before the component providing the needed search variable. A reliable fix for this is to make the search variable a control system output in the desired units, while the thermodynamic variable is the control system input in code internal (SI) units. The control system initial value can be set to the desired initial value of the search variable, and this will be used by the time-dependent table.

W1(R) Search variable (e.g., time).

W2-W7(R) Quantities as described under word 1 in Card 200. Depending on the control word, two through five quantities may be required. If entered, boron concentration follows the last required word for thermodynamic conditions.

As described above, sets may be entered one or more per card.

A7.4 Single-Junction Component

A single-junction component is indicated by SNGLJUN on card ccc0000. For major edits, minor edits, and plot variables, the junction in the single junction component is numbered ccc000000.

A7.4.1 Cards ccc0101 through ccc0109, Single-Junction Geometry Cards

This card (or cards) is required for single-junction components.

W1(I) From connection code to a component. This refers to the component from which the junction coordinate direction originates. For connecting to a time-dependent volume, the connection code is ccc000000, where ccc is the component number of the time-dependent volume. An old or an expanded format can be used to connect all other volumes. In the old format, use ccc000000 if the connection is to the inlet side of the component and use ccc010000 if the connection is to the outlet side of the component. In the expanded format, the connection code is cccvv000n, where cc is the component number, vv is the volume number, and n indicates the face number. A nonzero n specifies the expanded format. The number n equal to 1 and 2 specifies the inlet and outlet faces, respectively, for the volume's coordinate direction (see Section 2.1). The number n equal to 3 through 6 specifies crossflow. The number n equal to 3 and 4 would specify inlet and outlet faces for the second coordinate direction; n equal to 5 and 6 would do the same for the third coordinate direction.

W2(I) To connection code to a component. This refers to the component at which the junction coordinate direction ends. See the description for W1 above.

W3(R) Junction area (m^2, ft^2). If zero, the area is set to the minimum volume flow area of the adjoining volumes. For abrupt area changes, the junction area must be equal to or smaller than the minimum of the adjoining volume areas. For smooth area changes, there are no restrictions.

W4(R) Forward flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is positive or zero. Note: a variable loss coefficient may be specified. See Section A7.4.3.

W5(R) Reverse flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is negative. Note: a variable loss coefficient may be specified. See Section A7.4.3.

W6(I) Junction control flags. This word has the packed format efvcahs. It is not necessary to input leading zeros.

The digit e specifies the modified PV term in the energy equations. e=0 means that the modified PV term will not be applied, and e=1 means that it will be applied.

The digit f specifies CCFL options. f=0 means that the CCFL model will not be applied, and f=1 means that it will be applied.

The digit v specifies horizontal stratification entrainment/ pullthrough options. This model is for junctions connected to a horizontal volume. v=0 means the model is not applied; v=1 means an upward-oriented junction; v=2 means a downward-oriented junction; and v=3 means a centrally (side) located junction.

The digit c specifies choking options. c=0 means that the choking model will be applied, and c=1 means that the choking model will not be applied.

The digit a specifies area change options. a=0 means either a smooth area change or no area change, and a=1 means an abrupt area change.

The digit h specifies nonhomogeneous or homogeneous. h=0 specifies the nonhomogeneous (two velocity momentum equations) option, and h=2 specifies the homogeneous (single velocity momentum equation) option. For the homogeneous option (h=2), the major edit printout will show a 1.

The digit s specifies momentum flux options. s=0 uses momentum flux in both the to volume and the from volume. s=1 uses momentum flux in the from volume, but not in the to volume. s=2 uses momentum flux in the to volume, but not in the from volume; s=3 does not used momentum flux in either the to or the from volume.

W7(R) Subcooled discharge coefficient. This quantity is applied only to subcooled liquid choked flow calculations. The quantity must be >0.0 and ≤2.0. If missing, it is set to 1.0.

W8(R) Two-phase discharge coefficient. This quantity is applied only to two-phase choked flow calculations. The quantity must be >0.0 and ≤2.0. If missing, it is set to1.0.

W9(R) Superheated discharge coefficient. This quantity is applied only to superheated vapor choked flow calculations. The quantity must be >0.0 and ≤2.0. If missing, it is set to 1.0.

A7.4.2 Card ccc0110, Single-Junction Diameter and CCFL Data Card

This card is optional. The defaults indicated for each word are used if the card is not entered. If this card is being used to specify only the junction hydraulic diameter for the interphase drag calculation (i.e., f=0 in Word 6 of Cards ccc0101-ccc0109), then, the diameter should be entered in Word 1 and any allowable values should be entered in Words 2 through 4 (will not be used). If this card is being used for the CCFL model (i.e., f=1 in Word 6 of Cards ccc0101-ccc0109), then enter all four words for the appropriate CCFL model if values different from the default values are desired.

W1(R) Junction hydraulic diameter, D_j (m, ft). This quantity is the junction hydraulic diameter used in the CCFL correlation equation and interphase drag and must be ≥ 0. This number should be computed from 4.0*(junction area)/(wetted perimeter). If zero is entered or if the default is used, the junction diameter is computed from 2.0*(junction area/π)**0.5. See Word 3 of Cards ccc0101-ccc0109 for the junction area.

W2(R) Flooding correlation form, β. If zero, the Wallis CCFL form is used. If one, the Kutateladze CCFL form is used. If between zero and one, Bankoff weighting between the Wallis and Kutateladze CCFL forms is used. This number must be ≥ 0 and ≤ 1. The default value is 0 (Wallis form). See Section 3 of Volume I for details of the model.

W3(R) Gas intercept, c. This quantity is the gas intercept used in the CCFL correlation (when $H_f^{1/2} = 0$) and must be > 0. The default value is 1.

W4(R) Slope, m. This quantity is the slope used in the CCFL correlation and must be > 0. The default value is 1.

A7.4.3 Card ccc0111, Single-Junction Form Loss Data Card

This card is optional. The user-specified form loss is given in Words 4 and 5 of Card ccc0101 if this card is not entered. If this card is entered, the form loss coefficient is calculated from

$$K_f = A_f + B_f Re^{-c_f}$$

$$K_r = A_r + B_r Re^{-c_r}$$

where K_f and K_r are the forward and reverse form loss coefficient. A_f and A_r are the Words 4 and 5 of Card ccc0101. Re is the Reynolds number based on mixture fluid properties. If this card is being used for the form loss calculation, then enter all four words for the appropriate expression.

W1(R) B_f (≥ 0). This quantity must be greater than or equal to zero.

W2(R) c_f (≥ 0). This quantity must be greater than or equal to zero.

W3(R) B_r (≥ 0). This quantity must be greater than or equal to zero.

W4(R) c_r (≥ 0). This quantity must be greater than or equal to zero.

A7.4.4 Card ccc0201, Single-Junction Initial Conditions

This card is required for single-junction components.

W1(I) Control word. If zero, the next two words are velocities; if one, the next two words are mass flows.

W2(R) Initial liquid velocity or mass flow. This quantity is either velocity (m/s, ft/s) or mass flow (kg/s, lb/s), depending on the control word.

W3(R) Initial vapor velocity or mass flow. This quantity is either velocity (m/s, ft/s) or mass flow (kg/s, lb/s), depending on the control word.

W4(R) Interface velocity (m/s, ft/s). Enter zero.

A7.5 Time-Dependent Junction Component

This component is indicated by TMDPJUN on Card ccc0000. For major edits, minor edits, and plot variables, the junction in the time-dependent junction component is numbered as ccc000000.

A7.5.1 Card ccc0101, Time-Dependent Junction Geometry Card

This card is required for time-dependent junction components.

W1(I) From connection code to a component. This refers to the component from which the junction coordinate direction originates. For connecting to a time dependent volume, the connection code is ccc000000, where ccc is the component number of the time dependent volume. An old or an expanded format can be used to connect all other volumes. In the old format, use ccc000000 if the connection is to the inlet side of the component and use ccc010000 if the connection is to the outlet side of the volume. In the expanded format, the connection code is cccvv000n, where ccc is the component number, vv is the volume number, and n indicates the face number. A nonzero n specifies the expanded format. The number n equal to 1 and 2 specifies the inlet and outlet faces respectively or the volume's coordinate direction (see Section 2.1). The number n equal to 3 through 6 specifies crossflow. The number n equal to 3 and 4 would specify inlet and outlet faces for the second coordinate direction; n equal to 5 and 6 would do the same for the third coordinate direction.

W2(I) To connection code to a component. This refers to the component at which the junction coordinate direction ends. See the description for W1 above.

W3(R) Junction area (m^2, ft^2). If zero, the area is set to the minimum flow area of the adjoining volumes. There are no junction area restrictions for time dependent junctions.

A7.5.2 Card ccc0200, Time-Dependent Junction Data Control Word

This card is optional. If this card is missing, the second and third words of the time-dependent data are assumed to be velocities.

W1(I) Control word. If zero, the second and third words of the time-dependent junction data in Cards ccc0201 through ccc0299 are velocities. If one, the second and third words of the time-dependent junction data in Cards ccc0201 through ccc0299 are mass flows. In both cases, the fourth word is interface velocity and should be entered as zero.

W2(I) Table trip number. This word is optional. If missing or zero and Word 3 is missing, no trip is used, and the time argument is the advancement time. If nonzero and Word 3 is missing, this number is the trip number and the time argument is -1.0 if the trip is false, and the advancement time minus the trip time if the trip is true.

W3(A) Alphanumeric part of variable request code. This quantity is optional. If present, this word and the next are a variable request code that specifies the search argument for the table lookup and interpolation. If the trip number is zero, the specified argument is always used. If the trip number is nonzero, -1.0E75 is used if the trip is false, and the specified argument is used if the trip is true. TIME can be selected, but note that the trip logic is different than if this word is omitted.

W4(I) Numeric part of variable request code. This is assumed zero if missing.

A7.5.3 Cards ccc0201 through ccc0299, Time-Dependent Junction Data Cards

These cards are required for time-dependent junction components. A set of data consists of the search variable (e.g., time) followed by the required data indicated by control word 1 on card ccc0200. The card numbers need not be consecutive, but the value of the search variable in a succeeding set must be equal to or greater than the value in the previous set. One or more sets of data up to 5000 sets may be entered. Zero may be entered for a velocity or flow if the phase or material is not present. The interpolation and card formats for the time-dependent data are identical to that in Section A7.3.3 (Cards ccc0201-ccc0209, Time-Dependent Volume Data Cards).

When doing a single phase problem and entering velocities here, the same value should be entered for both liquid and vapor velocities. If entering mass flows, the correct value should be entered for either liquid or vapor (whichever single phase is being modeled) and the other entry should be zero.

If the user wants to specify the vapor void fraction as a function of time in the time-dependent volume, and the total mass flow as a function of time in the time-dependent junction, then both the phasic (gas and liquid) mass flow rates must be calculated and entered in these cards.

W1(R) Search variable (e.g., time).

W2(R) Liquid velocity or mass flow. This quantity is either velocity (m/s, ft/s) or mass flow (kg/s, lb/s), depending on control word 1 on card ccc0200.

W3(R) Vapor velocity or mass flow. This quantity is either velocity (m/s, ft/s) or mass flow (kg/s, lb/s), depending on control word 1 on card ccc0200.

W4(R) Interface velocity (m/s, ft/s). Enter zero.

As described above, sets may be entered one or more per card.

A7.6 Pipe, Annulus Component

A pipe component is indicated by PIPE, an annulus component is indicated by ANNULUS on Card ccc0000. The PIPE and ANNULUS components are similar, except that the ANNULUS component must be vertical and all the water is in the film (i.e., no drops) when in the annular-mist flow regime. The remaining input for both components is identical. More than one junction may be connected to the inlet or outlet. If an end has no junctions, that end is considered a closed end. For major edits, minor edits, and plot variables, the volumes in the pipe component are numbered as cccnn0000, where nn is the volume number (greater than 00 and less than 100). The junctions in the pipe component are numbered as cccmm0000, where mm is the junction number (greater than 00 and less than 99).

The input for a pipe or annulus component assumes that the pipe has at least two volumes with one junction separating the two volumes. It is possible to input a one-volume pipe or annulus. In order to implement this special case, the user must set the number of volumes and the volume number on the volume cards to one. In addition, the user should not input any of the junction cards.

The volumes in a pipe are usually considered one-dimensional components and flow in the volumes is along the x-coordinate. Cross flow junctions can connect the pipe volumes in the y and z-coordinate directions using a form of the momentum equation that does not include momentum flux terms. Optional input may be added that allow the full one-dimensional momentum equations to be used in the y- and z-coordinate directions.

A7.6.1 Card ccc0001, Pipe, Annulus Information Card

This card is required for pipe components.

W1(I) Number of volumes, nv. nv must be greater than zero and less than 100. The number of associated junctions internal to the pipe is nv-1. The outer junctions are described by other components.

A7.6.2 Cards ccc0101 through ccc0199, Pipe, Annulus X-Coordinate Volume Flow Areas

The format is two words per set in sequential expansion format for nv sets. These cards are required, and the card numbers need not be consecutive. The words for one set are

W1(R) Volume flow area (m^2, ft^2).

W2(I) Volume number.

A7.6.3 Cards ccc1601 through ccc1699, Pipe, Annulus Y-Coordinate Volume Flow Areas

The format is two words per set in sequential expansion format for nv sets. These cards are optional and if entered activate the y-coordinate for each volume and allow the full one-dimensional momentum equations to be used in connections to the y faces. The card numbers need not be consecutive. The words for one set are:

W1(R) Volume flow area (m^2, ft^2).

W2(I) Volume number.

A7.6.4 Cards ccc1701 through ccc1799, Pipe, Annulus Z-Coordinate Volume Flow Areas

The format is two words per set in sequential expansion format for nv sets. These cards are optional and if entered activate the z-coordinate for each volume and allow the full one-dimensional momentum equations to be used in connections to the z faces. The card numbers need not be consecutive. The words for one set are:

W1(R) Volume flow area (m^2, ft^2).

W2(I) Volume number.

A7.6.5 Cards ccc0201 through ccc0299, Pipe, Annulus Junction Flow Areas

These cards are optional, and, if entered, the card numbers need not be consecutive. The format is two words per set in sequential expansion format for nv-1 sets.

W1(R) Internal junction flow area (m^2, ft^2). If cards are missing or a word is zero, the junction flow area is set to the minimum area of the adjoining volumes. For abrupt area changes, the junction area must be equal to or less than the minimum of the adjacent volume areas. There is no restriction for smooth area changes.

W2(I) Junction number.

A7.6.6 Cards ccc0301 through ccc0399, Pipe, Annulus X-Coordinate Volume Lengths

These cards are required for pipe components. The format is two words per set in sequential expansion format for nv sets. Card numbers need not be consecutive.

W1(R) Pipe volume length (m, ft).

W2(I) Volume number.

A7.6.7 Cards ccc1801 through ccc1899, Pipe, Annulus Y-Coordinate Volume Lengths

These cards are optional and if entered activate the y-coordinate for each volume and allow the full one-dimensional momentum equation for connections to the y faces. The format is two words per set in sequential expansion format for nv sets. Card numbers need not be consecutive.

W1(R) Pipe volume length (m, ft).

W2(I) Volume number.

A7.6.8 Cards ccc1901 through ccc1999, Pipe, Annulus Z-Coordinate Volume Lengths

These cards are optional and if entered activate the z-coordinate for each volume and allow the full one-dimensional momentum equation for connections to the z faces. The format is two words per set in sequential expansion format for nv sets. Card numbers need not be consecutive.

W1(R) Pipe volume length (m, ft).

W2(I) Volume number.

A7.6.9 Cards ccc0401 through ccc0499, Pipe, Annulus Volume Volumes

The format is two words per set in sequential expansion format for nv sets. Card numbers need not be consecutive.

W1(R) Volume (m^3, ft^3). If these cards are missing, volumes equal to zero are assumed. The code requires that each volume equal the flow area times length. For any volume, at least two of the three quantities, area, length, or volume, must be nonzero. If one of the quantities is zero, it will be computed from the other two. If none of the quantities are zero, the volume must equal the area times the length within a relative error of 0.000001.

W2(I) Volume number.

A7.6.10 Cards ccc0501 through ccc0599, Pipe, Annulus Volume Azimuthal Angles

These cards are optional, and, if not entered, the angles are set to zero. The format is two words per set in sequential expansion format for nv sets, and card numbers need not be consecutive.

W1(R) Azimuthal angle (degrees). The absolute value of the angle must be $\leq$ 360 degrees.

W2(I) Volume number.

A7.6.11 Cards ccc0601 through ccc0699, Pipe, Annulus Volume Vertical Angles

These cards are required for pipe components. The format is two words per set in sequential expansion format for nv sets, and card numbers need not be consecutive.

W1(R) Vertical angle (degrees). The absolute value of the angle must be less than or equal to 90 degrees. This angle is used in the interphase drag calculation.

W2(I) Volume number.

A7.6.12 Cards ccc0701 through ccc0799, Pipe, Annulus X-Coordinate (Elevation) Changes

These cards are optional. If these cards are missing, the coordinate changes or elevation changes are computed from the x-coordinate volume length and a rotation matrix computed from the angle information. If these cards are entered, the entered data becomes the x-coordinate change or elevation change data. Two formats entering one or three coordinate changes per volume are provided. The card format is two or four words per set in sequential expansion format up to nv sets, and card numbers need not be consecutive.

One Coordinate Change Per Volume Format:

W1(R) Elevation change. This is the coordinate change along the fixed z-axis due to the traverse from inlet to outlet along the local x-coordinate, Δ_{zx} (m, ft). A positive value is an increase in elevation. The magnitude must be equal to or less than the volume length. When the absolute value of the elevation angle determined by the ratio of the elevation change (this Word 6) and the volume length (Word 2) is less than or equal to 45 degrees, the horizontal flow regime map is used; when the ratio is greater than 45 degrees, the vertical flow regime map is used.

W2(I) Volume number.

Three Coordinate Changes Per Volume Format:

W1(R) Coordinate change along the fixed x-axis due to traverse from inlet to outlet along the local x-coordinate, Δ_{xx}, (m, ft).

W2(R) Coordinate change along the fixed y-axis due to traverse from inlet to outlet along the local x-coordinate, Δ_{yx}, (m, ft).

W3(R) Coordinate change along the fixed z-axis due to traverse from inlet to outlet along the local x-coordinate, Δ_{zx}, (m, ft).

W4(I) Volume number.

A7.6.13 Cards ccc2101 through ccc2199, Pipe, Annulus Y-Coordinate (Elevation) Changes

These cards are optional. If these cards are missing, the coordinate changes are computed from the y-coordinate volume length and a rotation matrix computed from the angle information. If these cards are entered, the entered data overwrites the previously computed coordinate change data. The card format is four words per set in sequential expansion format up to nv sets, and card numbers need not be consecutive.

W1(R) Coordinate change along fixed x-axis due to traverse from inlet to outlet along the local y-coordinate, Δ_{xy} (m, ft).

W2(R) Coordinate change along fixed y-axis due to traverse from inlet to outlet along the local y-coordinate, Δ_{yy} (m, ft).

W3(R) Coordinate change along fixed z-axis due to traverse from inlet to outlet along the local y-coordinate, Δ_{zy} (m, ft).

W4(I) Volume number.

A7.6.14 Cards ccc2201 through ccc2299, Pipe, Annulus Z-Coordinate (Elevation) Changes

These cards are optional. If these cards are missing, the coordinate changes are computed from the z-coordinate volume length and a rotation matrix computed from the angle information. If these cards are entered, the entered data overwrites the previously computed coordinate change data. The card format is four words per set in sequential expansion format up to nv sets, and card numbers need not be consecutive.

W1(R) Coordinate change along fixed x-axis due to traverse from inlet to outlet along the local z-coordinate, Δ_{xz} (m, ft).

W2(R) Coordinate change along fixed y-axis due to traverse from inlet to outlet along the local z-coordinate, Δ_{yz} (m, ft).

W3(R) Coordinate change along fixed z-axis due to traverse from inlet to outlet along the local z-coordinate, Δ_{zz} (m, ft).

W4(I) Volume number.

A7.6.15 Cards ccc0801 through ccc0899, Pipe, Annulus Volume X-Coordinate Friction Data

These cards are required for pipe components. The card format is three words per set for nv sets, and card numbers need not be consecutive.

W1(R) Wall roughness (m, ft).

W2(R) Hydraulic diameter (m, ft). This should be computed from 4.0*(volume flow area)/(wetted perimeter). If zero, the hydraulic diameter is computed from 2.0*(volume flow area/π)**0.5. A check is made to ensure that the roughness is less than half the hydraulic diameter. See Word 1 on Cards ccc0101-ccc0109 for the volume flow area.

W3(I) Volume number.

A7.6.16 Cards ccc2301 through ccc2399, Pipe, Annulus Volume Y-Coordinate Friction Data

These cards are optional and may be entered if volume flow area or volume length data was entered for the y-coordinate. If the cards are not entered, the wall roughness defaults to zero and the default hydraulic diameter is computed as if zero was entered in Word 2. The format for these cards is the same as for the friction data for the x-coordinate (Section A7.6.15).

A7.6.17 Cards ccc2401 through ccc2499, Pipe, Annulus Volume Z-Coordinate Friction Data

These cards are optional and may be entered if volume flow area or volume length data was entered for the y-coordinate. If the cards are not entered, the wall roughness defaults to zero and the default hydraulic diameter is computed as if zero was entered in Word 2. The format for these cards is the same as for the friction data for the x-coordinate (Section A7.6.15).

A7.6.18 Cards ccc2501 through ccc2599, Pipe, Annulus Volume Additional Laminar Wall

Friction Data

These cards are optional. If these cards are not entered, the default values are 1.0 for the shape factor and 0.0 for the viscosity ratio exponent. The card format is seven words per set in sequential expansion format for nv sets and card numbers need not be consecutive.

W1(R) Shape factor for x-coordinate.

W2(R) Viscosity ratio exponent for x-coordinate.

W3(R) Shape factor for y-coordinate.

W4(R) Viscosity ratio exponent for y-coordinate.

W5(R) Shape factor for z-coordinate.

W6(R) Viscosity ratio exponent for z-coordinate.

W7(I) Volume number.

A7.6.19 Cards ccc0901 through ccc0999, Pipe, Annulus Junction Loss Coefficients

These cards are optional and if missing, the energy loss coefficients are set to zero. The card format is three words per set in sequential expansion format for nv-1 sets, and card numbers need not be consecutive.

W1(R) Forward flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is positive or zero. Note: a variable loss coefficient may be specified. See Section A7.6.29.

W2(R) Reverse flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is negative. Note: a variable loss coefficient may be specified. See Section A7.6.29.

W3(I) Junction number.

A7.6.20 Cards ccc1001 through ccc1099, Pipe, Annulus Volume X-Coordinate Control Flags

These cards are required for pipe volumes. The card format is two words per set in sequential expansion format for nv sets, and card numbers need not be consecutive.

W1(I) Volume control flags. This word has the packed format tlpvbfe. It is not necessary to input leading zeros. Volume flags consist of scaler oriented and coordinate direction oriented flags. Only one value for a scaler oriented flag is entered per volume but up to three coordinate oriented flags can be entered for a volume, one for each coordinate direction. At present, the f flag is the only coordinate direction oriented flag. These words enter the scaler oriented flags and the x coordinate flags for each volume in the pipe.

. The digit t specifies whether the thermal front tracking model is to be used; t=0 specifies that the front tracking model is not to be used for the volume, and t=1 specifies that the front tracking model is to be used for the volume. The thermal front tracking model can only be applied to vertically-oriented components.

The digit l specifies whether the mixture level tracking model is to be used; l=0 specifies that the level model not be used for the volume, and l=1 specifies that the level model be used for the volume. The mixture level tracking model can only be applied to vertically-oriented components.

The digit p specifies whether the water packing scheme is to be used. p=0 specifies that the water packing scheme is to be used for the volume, and p=1 specifies that the water packing scheme is not to be used for the volume. The water packing scheme is recommended when modeling a pressurizer.

The digit v specifies whether the vertical stratification model is to be used. v=0 specifies that the vertical stratification model is to be used for the volume, and v=1 specifies that the vertical stratification model is not to be used for the volume. The vertical stratification model is recommended when modeling a pressurizer.

The digit b specifies the interphase friction that is used. b=0 means that the pipe interphase friction model will be applied, and b=1 means that the rod bundle interphase friction model will be applied.

The digit f specifies whether wall friction is to be computed. f=0 specifies that wall friction effects are to be computed along the x coordinate of the volume, and f=1 specifies that wall friction effects are not to be computed along the x coordinate.

The digit e specifies if nonequilibrium or equilibrium is to be used. e=0 specifies that a nonequilibrium (unequal temperature) calculation is to be used, and e=1 specifies that an equilibrium (equal temperature) calculation is to be used. Equilibrium volumes should not be connected to nonequilibrium volumes. The equilibrium option is provided only for comparison to other codes.

W2(I) Volume number.

A7.6.21 Cards ccc2701 through ccc2799, Pipe, Annulus Y-Coordinate Control Flags

W1(I) Volume control flags. This word has the general packed format tlpvbfe, but this word is limited to 00000f0 since it only enters the coordinate oriented flags for the y direction.

The digit f specifies whether wall friction is to be computed. f=0 specifies that wall friction effects are to be computed along the y coordinate direction in the volume, and f=1 specifies that wall friction effects are not to be computed along the y coordinate direction.

W2(I) Volume number.

A7.6.22 Cards ccc2801 through ccc2899, Pipe, Annulus Z-Coordinate Control Flags

W1(I) Volume control flags. This word has the general packed format tlpvbfe, but this word is limited to 00000f0 since it only enters the coordinate oriented flags for the z direction.

The digit f specifies whether wall friction is to be computed. f=0 specifies that wall friction effects are to be computed along the z coordinate direction in the volume, and f=1 specifies that wall friction effects are not to be computed along the z coordinate direction.

W2(I) Volume number.

A7.6.23 Cards ccc1101 through ccc1199, Pipe, Annulus Junction Control Flags

These cards are required for pipe components. The card format is two words per set in sequential expansion format for nv-1 sets, and card numbers need not be consecutive.

W1(I) Junction control flags. This word has the packed format efvcahs. It is not necessary to input leading zeros.

The digit e specifies the modified PV term in the energy equations. e=0 means that the modified PV term will not be applied, and e=1 means that it will be applied.

The digit f specifies CCFL options. f=0 means that the CCFL model will not be applied, and f=1 means that the CCFL model will be applied.

The digit v is not used and should be input as zero (v=0). The horizontal stratification entrainment/pullthrough model cannot be used.

The digit c specifies choking options. c=0 means that the choking model will be applied, and c=1 means that the choking model will not be applied.

The digit a specifies area change options. a=0 means either a smooth area change or no area change, and a=1 means an abrupt area change.

The digit h specifies nonhomogeneous or homogeneous. h=0 specifies the nonhomogeneous (two-velocity momentum equations) option, and h=2 specifies the homogeneous (single velocity momentum equation) option. For the homogeneous option (h=2), the major edit printout will show a one.

The digit s is not used and should be input as zero (s=0).

W2(I) Junction number.

A7.6.24 Cards ccc1201 through ccc1299, Pipe, Annulus Volume Initial Conditions

These cards are required for pipe components. The card format is seven words per set in sequential expansion format for nv sets, and card numbers need not be consecutive.

W1(I) Control word. This word has the packed format εbt. It is not necessary to input leading zeros.

The digit ε specifies the fluid. ε=0 is the default fluid, ε=1 specifies H_2O, ε=2 specifies D_20, and ε=3 specifies H_2. The default fluid is that set for the hydrodynamic system by Cards 120 through 129 or this control word in another volume in this hydrodynamic system. The fluid type set on Cards 120 through129 or these control words must be consistent (i.e., not specify different fluids). If Cards120 through129 are not entered and all control words use the default ε=0, then H_2O is assumed as the fluid.

The digit b specifies whether boron is present or not. b=0 specifies that the volume fluid does not contain boron; b=1 specifies that a boron concentration in parts of boron per parts of liquid (which may be zero) is being entered after the other required thermodynamic information.

The digit t specifies how the following words are to be used to determine the initial thermodynamic state. Entering t equal to 0 through 3 specifies one component (steam/ water). Entering t equal to 4 through 6 allows the specification of two components (steam/ water and noncondensable gas).

If t=0, the next four words are interpreted as pressure (Pa, lb_f/in^2), liquid specific internal energy (J/kg, Btu/lb), vapor specific internal energy (J/kg, Btu/lb), and vapor void fraction. These quantities will be interpreted as nonequilibrium or equilibrium conditions, depending on the volume control flag. If equilibrium, the static quality is checked, but only the pressure and internal energies are used to define the thermodynamic state. W6 should be 0.0.

If t=1, the next two words are interpreted as temperature (K, ^oF) and quality in equilibrium condition. W4, W5, and W6 should be 0.0.

If t=2, the next two words are interpreted as pressure (Pa, lb_f/in^2) and quality in equilibrium condition. W4, W5, and W6 should be 0.0.

If t=3, the next two words are interpreted as pressure (Pa, lb_f/in^2) and temperature (K, ^oF) in equilibrium condition. W4, W5, and W6 should be 0.0.

The following options are used for input of noncondensable states only. In all cases, the criteria used for determining the range of values for quality are

1.0E-9 $\leq$ quality $\leq$ 0.99999999, two-phase conditions, and quality < 1.0E-9 or quality > 0.99999999, single phase.

Noncondensable options are as follows:

If t=4, the next three words are interpreted as pressure (Pa, lb_f/in^2), temperature (K, ^oF), and equilibrium quality. Using this input option with quality >0.0 and $\leq$1.0, saturated noncondensables will result. W5 and W6 should be 0.0. Also, the temperature is restricted to be less than the saturation temperature at the input pressure. Setting quality to 0.0 is used as a flag that will initialize the volume to all noncondensable (dry noncondensable) with no temperature restrictions. Quality is reset to 1.0 using this dry noncondensable option.

If t=5, the next three words are interpreted as temperature (K, ^{o}F), equilibrium quality, and noncondensable quality. Both the equilibrium and noncondensable qualities are restricted to be between 1.0E-9 and 0.99999999. W5 and W6 should be 0.0. Little experience has been obtained using this option, and it has not been checked out.

If t=6, the next five words are interpreted as pressure (Pa, lb_f/in^2), liquid specific internal energy (J/kg, Btu/lb), vapor specific internal energy (J/kg, Btu/lb), vapor void fraction, and noncondensable quality. The combinations of vapor void fraction and noncondensable quality must be thermodynamically consistent. If noncondensable quality is set to 0.0, noncondensables are not present and the input processing branches to that type of processing. If noncondensables are present (noncondensable quality greater than 0.0), then the vapor void fraction must not be 0.0. If the noncondensable quality is set to 1.0 (pure noncondensable), then vapor void fraction must also be 1.0. When both the vapor void fraction and the noncondensable quality are set to 1.0, the volume temperature is calculated from the noncondensable energy equation using the input vapor-specific internal energy.

W2-W6(R) Quantities as described under Word 1. Five quantities must be entered, and zeros should be entered for unused quantities. If any control word (Word 1) indicates that boron is present, Cards ccc2001 through ccc2099 must be entered to define the initial boron concentrations. Boron concentrations are not entered in Words 2 through 6.

W7(I) Volume number.

A7.6.25 Cards ccc2001 through ccc2099, Pipe, Annulus Initial Boron Concentrations

These cards are required only if boron is specified in one of the control words (Word 1) in Cards ccc1201 through ccc1299. The card format is two words per set in sequential expansion format for nv sets. Boron concentrations must be entered for each volume, and zero should be entered for those volumes whose associated control word did not specify boron.

W1(R) Boron concentration. Parts of boron per parts of liquid.

W2(I) Volume number.

A7.6.26 Card ccc1300, Pipe, Annulus Junction Conditions Control Words

This card is optional, and, if missing, velocities are assumed on Cards ccc1301 through ccc1399.

W1(I) Control word. If zero, the first and second words of each set on Cards ccc1301 through ccc1399 are velocities. If one, the first and second words of each set on Cards ccc1301 through ccc1399 are mass flows.

A7.6.27 Cards cc1301 through ccc1399, Pipe, Annulus Junction Initial Conditions

W1(R) Initial liquid velocity or mass flow (velocity in m/s, ft/s or mass flow in kg/s, lb/s).

W2(R) Initial vapor velocity or mass flow (velocity in m/s, ft/s or mass flow in kg/s, lb/s).

W3(R) Interface velocity (m/s, ft/s). Enter zero.

W4(I) Junction number.

A7.6.28 Cards ccc1401 through ccc1499, Pipe, Annulus Junction Diameter and CCFL Data Cards

These cards are optional. The defaults indicated for each word are used if the card is not entered. If this card is being used to specify only the junction hydraulic diameter for the interphase drag calculation, (i.e., f=0 in Word 1 of Cards ccc1101-ccc1199) then the diameter should be entered in Word 1 and any allowable values should be entered in Words 2 through 4 (will not be used). If this card is being used for the CCFL model (i.e., f=1 in Word 1 of Cards ccc1101-ccc1199), then enter all four words for the appropriate CCFL model if values different from the default value are desired.

W1(R) Junction hydraulic diameter, D_j (m, ft). This quantity is the junction hydraulic diameter used in the CCFL correlation equation and interphase drag and must be $\geq$0. The number should be computed from 4.0*(junction area)/(wetted perimeter). If a zero is entered or if the default is used, the junction diameter is computed from 2.0*(junction area/π)**0.5. See Word 1 of Cards ccc0201-ccc0299 for the junction area.

W2(R) Flooding correlation form, β. If zero, the Wallis CCFL form is used. If one, the Kutateladze CCFL form is used. If between zero and one, Bankoff weighting between the Wallis and Kutateladze CCFL forms is used. This number must be $\geq$0 and $\leq$1. The default value is 0 (Wallis form).

W3(R) Gas intercept, c. This quantity is the gas intercept used in the CCFL correlation (when $H_f^{1/2} = 0$) and must be > 0. The default value is 1.

W4(R) Slope, m. This quantity is the slope used in the CCFL correlation and must be >0. The default value is 1.

W5(I) Junction number.

A7.6.29 Card ccc3001 through ccc3099, Pipe, Annulus Junction Form Loss Data Card

This card is optional. The user specified form loss is given in Words 1 and 2 of Cards ccc0901 through ccc0999 if this card is not entered. If this card is entered, the form loss coefficient is calculated from

$$K_f = A_f + B_f Re^{-c_f}$$

$$K_r = A_r + B_r Re^{-c_r}$$

where K_f and K_r are the forward and reverse form loss coefficient. A_f and A_r are the Words 1 and 2 of Cards ccc0901 through ccc0999. Re is the Reynolds number based on mixture fluid properties. If this card is being used for the form loss calculation, then enter all five words for the appropriate expression.

W1(R) B_f (≥ 0). This quantity must be greater than or equal to zero.

W2(R) c_f (≥ 0). This quantity must be greater than or equal to zero.

W3(R) B_r (≥ 0). This quantity must be greater than or equal to zero.

W4(R) c_r (≥ 0). This quantity must be greater than or equal to zero.

W5(I) Junction number.

A7.7 Branch, Separator, Jetmixer, Turbine, or ECC Mixer Component

A branch component is indicated by BRANCH, a steam separator is indicated by SEPARATR, a jetmixer is indicated by JETMIXER, a turbine is indicated by TURBINE, and an ECC mixer is indicated by ECCMIX on Card ccc0000. In junction references using the old format, the code for the component inlet is ccc000000 and the code for the component outlet is ccc010000. In the junction references using the expanded format, the connection code is cccvv00n, where ccc is the component number, vv is the volume number, and n is the face number. More than one junction may be connected to the inlet or outlet. If an end has no junctions, that end is considered a closed end. Normally, only a branch has more than one junction connected to a volume end. Multiple junctions may connect to the ends of pipes and single volumes, except that a warning message is issued even though the connections are handled correctly. Limiting multiple connections to branch components allows the warning message to indicate probable input error. If more than one junction is connected on one end of a branch, each junction should be modeled as an abrupt area change. For major edits, minor edits, and plot variables, the volume in the branch component is numbered as ccc010000. The junctions associated with the branch component are numbered as cccmm0000, where mm is the junction number (greater than 00 and less than 10).

A separator component is a specialized branch component having three junctions. nj defined below must be three, and no junctions in other components may connect to this component. N defined below must have values of 1, 2, and 3. For the junctions, n=1 is the vapor outlet, n=2 is the liquid fall back, and n=3 is the separator inlet. The from part of the vapor outlet junction must refer to outlet of the separator (cc010000), and the from part of the liquid fall back must refer to the inlet of the separator (ccc000000). To include the direct path from a steam generator downcomer to the steam dome, a bypass volume is recommended. The smooth or abrupt junction option can be used for the three junctions. Appropriate user input energy loss coefficients may be needed to match a known pressure drop across the separator. We recommend that choking be turned off for all three junctions. The vapor outlet and liquid fall back junctions should use the nonhomogeneous option. The CCFL flag must be turned off (f=0) for all three junctions. The horizontal stratification flag is not used for separator junctions and should be set to zero (v=0). The rod bundle interphase friction flag must be turned off (b=0) in the separator volume. The vertical stratification model flag is not used in the separator volume and should be set to zero (v=0). The water packing scheme flag is not used in the separator volume and should be set to zero (p=0).

A jetmixer component is a specialized branch using three junctions numbered in the same manner as the separator. For the junctions, n=1 represents the drive, n=2 represents the suction, and n=3 represents the discharge. The to part of the drive and suction junctions must refer to the inlet end of the jetmixer (ccc000000), and the from part of the discharge junction must refer to the outlet end of the jetmixer (ccc010000). To model a jet pump properly, the junction flow areas of the drive and suction should equal the volume flow area. The CCFL flag must be turned off (f=0) for all three junctions. The horizontal stratification flag is not used for jetmixer junctions and should be set to zero (v=0). The rod bundle interphase friction flag must be turned off (b=0) in the jetmixer volume. The vertical stratification model flag is not used in the jetmixer volume and should be set to zero (v=0). The water packing scheme flag is not used in the jetmixer volume and should be set to zero (p=0).

A turbine component is a specialized branch with additional input to describe the turbine characteristics. A simple turbine might use only one turbine component. A multistage turbine with steam extraction points might require several turbine components. nj must be equal to 1 or 2. For the junctions, n=1 is the turbine junction that models the stages, and n=2 is the steam extraction (bleed) junction that must be crossflow. The primary steam inlet junction (n=1) is a normal junction, and the steam extraction line (n=2) is modeled as a crossflow junction. The turbine junction (n=1) must be the only entrance junction, and there must be only one exit junction (part of another component). The to part of the steam inlet junction (n=1) must refer to the inlet end of the turbine volume (ccc000000). A restriction currently exists such that the volume and junction upstream (usual flow) must be the numerically preceding volume and junction. For the first turbine, there must be an artificial turbine component preceding it (i.e., constant efficiency, with efficiency=0, turbine with h=0). The volume and junction upstream of the artificial turbine need not be the numerically preceding volume and junction. The inertia and the friction of this artificial turbine should be entered somewhat less than that of the normal turbines. The horizontal stratification flag must be turned off (v=0). If several turbine components are in series, the choking flag should be left on (c=0) for the first component but turned off for the other components (c=1). The smooth junction option (a=0) should be used at both inlet and outlet junctions. The inlet and outlet junctions must be input as homogeneous junctions (h=2). If a steam extraction (bleed) junction is present, it must be a crossflow junction (s=1, 2, or 3). The CCFL flag must be turned off (f=0) for both junctions. The rod bundle interphase friction flag must be turned off (b=0) in the turbine volume. The vertical stratification model flag is not used in the turbine volume and should be set to zero (v=0). The water packing scheme flag is not used in the turbine volume and should be set to zero (p=0).

An ECC mixer (ECCMIX) component is a specialized branch that requires three junctions with a certain numbering order. The physical extent of the ECC mixer is a length of the cold leg, or any other horizontal pipe, centered around the position of the ECC injection location. The length of this pipe segment should be equal to three times the inside diameter of the pipe (if the physical arrangement of the system permits). Junction number one (the lowest numbered junction) must be the ECC connection. This is, in some respects, similar to the drive junction of a jetmixer component. Junction number two (the junction with higher number than the first one) should be the one that is the flow inlet to this component in normal operation. The geometrical angle between the axis of junctions one and two is one of the necessary inputs, as will be specified later. The third, or discharge, junction is the normal outlet of flow through this pipe segment. The to part of junctions one and two must refer to the inlet end of the ECC mixer (ccc000000), and the from part of the discharge junction must refer to the outlet end of the ECC mixer (ccc010000).

Two or more ECCMIX components may be considered in modeling some piping. These may be connected in tandem and require at least one normal volume between them.

The component identification word on Card ccc0000 should be ECCMIX for the ECC mixer. This word directs the code to use a specific flow regime map and a specific interfacial heat transfer package for steam condensation.

A7.7.1 Card ccc0001, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Information Card

This card is required for branch components.

W1(I) Number of junctions, nj. nj is the number of junctions described in the input data for this component and must be equal to or greater than zero and less than ten. This number must be 3 for SEPARATR, JETMIXER, and ECCMIX components and must be 1 or 2 for TURBINE components. For BRANCH components, not all junctions connecting to the branch need be described with this component input, and NJ is not necessarily the total number of junctions connecting to the branch. Junctions described in single junctions, time dependent junctions, pumps, separators, jetmixers and other branches can be connected to this branch.

W2(I) Initial condition control. This word is optional and, if missing, the junction initial velocities in the first and second words on Cards cccn201 are assumed to be velocities. If zero, velocities are assumed; if nonzero, mass flows are assumed.

A7.7.2 Card ccc0002, Separator Component Options Card

This card is an optional card for a separator component. The first word specifies the separator option while the second word specifies the number of actual separator components represented by this RELAP5 SEPARATOR component. The second word is needed if the user uses the General Electric separator options

W1(I) Separator option, ISEPST. A value of 0 specifies the simple separator contained in previous versions of RELAP5 (default), a value of 1 specifies the General Electric dryer model, a value of 2 specifies a General Electric two stage separator, and a value of 3 specifies a three stage General Electric separator.

W2(I) Number of separator components represented by this RELAP5 component. The number is needed only if Word 1 has a value of two or three.

A7.7.3 Cards ccc0101 through ccc0109, Branch, Separator, Jetmixer, Turbine, Or ECC Mixer X-Coordinate Volume Data

This card (or cards) is required for branch, separator, jetmixer, turbine, and ECC mixer components. The nine words can be entered on one or more cards, and the card numbers need not be consecutive.

W1(R) Volume flow area (m^2, ft^2).

W2(R) Length of volume (m, ft).

W3(R) Volume of volume (m^3, ft^3). The code requires that the volume equals the volume flow area times the length (W3=W1*W2). At least two of the three quantities, W1, W2, and W3, must be nonzero. If one of the quantities is zero, it will be computed from the other two. If none of the words are zero, the volume must equal the area times the length within a relative error of 0.000001.

W4(R) Azimuthal angle (degrees). The absolute value of this angle must be $\leq$360 degrees. This quantity is not used in the calculation but is specified for possible automated drawing of nodalization diagrams.

W5(R) Inclination angle (degrees). The absolute value of this angle must be $\leq$90 degrees. The angle 0 degrees is horizontal, and positive angles have an upward inclination, i.e., the inlet is at the lowest elevation. This angle is used in the interphase drag calculation. For ECCMIX, the allowable inclination angle is less than $\pm$15 degrees. Any other value will be considered an input error.

W6(R) Elevation change (m, ft). A positive value is an increase in elevation. The absolute value of this quantity must be less than or equal to the volume length. If the vertical angle orientation is zero, this quantity must be zero. If the vertical angle is nonzero, this quantity must also be nonzero and have the same sign. When the absolute value of the elevation angle determined by the ratio of the elevation change (this Word 6) and the volume length (Word 2) is less than or equal to 45 degrees, the horizontal flow regime map is used. When the ratio is greater than 45 degrees, the vertical flow regime map is used. For ECCMIX, the ECC mixer flow regimes are used.

W7(R) Wall roughness (m, ft).

W8(R) Hydraulic diameter (m, ft). This should be computed from 4.0*(volume flow area)/(wetted perimeter). If zero, the hydraulic diameter is computed from 2.0*(volume flow area/π)**0.5. A check is made that the pipe roughness is less than half the hydraulic diameter. See Word 1 for the volume flow area.

W9(I) Volume control flags. This word has the packed format tlpvbfe. It is not necessary to input leading zeros. Volume flags consist of scaler oriented and coordinate direction oriented flags. Only one value for a scaler oriented flag is entered per volume but up to three coordinate oriented flags can be entered for a volume, one for each coordinate direction. At present, the f flag is the only coordinate direction oriented flag. This word enters the scaler oriented flags and the x coordinate flag.

The digit t specifies whether the thermal front tracking model is to be used; t=0 specifies that the front tracking model is not to be used for the volume, and t=1 specifies that the front tracking model is to be used for the volume. This model is not used for SEPARATR, JETMIXER, or ECCMIX components and the flag if entered as 1 is reset to 0 and is not considered an input error. This model is also not used for the TURBINE component but entering the digit as 1 is an input error.

The digit l specifies whether the mixture level tracking model is to be used; l=0 specifies that the level model not be used for the volume, and l=1 specifies that the level model be used for the volume. This model is not used for SEPARATR, JETMIXER, or ECCMIX components and the flag if entered as 1 is reset to 0 and is not considered an input error. This model is also not used for the TURBINE component but entering the digit as 1 is an input error.

The digit p specifies whether the water packing scheme is to be used. p=0 specifies that the water packing scheme is to be used for the volume, and p=1 specifies that the water packing scheme is not to be used for the volume. The water packing scheme is recommended when modeling a pressurizer. This digit is used for the BRANCH and ECCMIX components. For the SEPARATR, JETMIXER, and TURBINE components, the water packer scheme is not allowed, the digit is not used and may be input as 0 or 1. The major edit will show p=1.

The digit v specifies whether the vertical stratification model is to be used. v=0 specifies that the vertical stratification model is to be used for the volume, and v=1 specifies that the vertical stratification model is not to be used for the volume. The vertical stratification model is recommended when modeling a pressurizer. This digit is used for the BRANCH component. For the SEPARATR, JETMIXER, ECCMIX, and TURBINE components, the vertical stratification model is not allowed, the digit is not used and may be input as 0 or 1. The major edit will show v=1.

The digit b specifies the interphase friction that is used. b=0 means that the pipe interphase friction model will be applied, b=1 means that the rod bundle interphase friction model will be applied, and b=2 means that the narrow channel model will be applied. This digit is only used for the BRANCH component. For the SEPARATR, JETMIXER, ECCMIX, and TURBINE components, the rod bundle interphase friction is not allowed, the digit is not used and should be input as 0. The major edit will show b=0. The digit b must be entered as 0 for a TURBINE component.

The digit f specifies whether wall friction is to be computed. f=0 specifies that wall friction effects are to be computed along the x coordinate direction in the volume, and f=1 specifies that wall friction effects are not to be computed along the x coordinate. For a separator, either 0 or 1 may be entered; the code will set f=1 and no wall friction will be calculated. The digit f must be entered as 1 for a TURBINE component.

The digit e specifies if nonequilibrium or equilibrium is to be used. e=0 specifies that a nonequilibrium (unequal temperature) calculation is to be used, and e=1 specifies that an equilibrium (equal temperature) calculation is to be used. Equilibrium volumes should not be connected to nonequilibrium volumes. The equilibrium option is provided only for comparison to other codes.

A7.7.4 Cards ccc0181 through ccc0189, Branch, Separator, Jetmixer, or ECC Mixer Y-Coordinate Volume Data

These cards are optional for BRANCH, SEPARATR, JETMIXER, and ECCMIX components but are not allowed for TURBINE components. These cards are used when the user specifies the y-direction connection with the crossflow model.

W1(R) Area of the volume (m^2).

W2(R) Length of the crossflow volume (m).

W3(R) Roughness.

W4(R) Hydraulic diameter (m).

W5(I) Volume control flags. This word has the general packed format tlpvbfe, but this word is limited to 00000f0 since it only enters the coordinate oriented flags for the y direction.

The digit f specifies whether wall friction is to be computed. f=0 specifies that wall friction effects are to be computed along the y coordinate direction in the volume, and f=1 specifies that wall friction effects are not to be computed along the y coordinate direction.

W6(R) This word is not used. Enter 0.

W7(R) This word is not used. Enter 0.

W8(R) This word is the position change in the z fixed (vertical) direction as the flow passes from the y inlet face to the y outlet face (m, ft). This quantity affects problems if connections are made to the y faces.

A7.7.5 Cards ccc0191 through ccc0199, Branch, Separator, Jetmixer, or ECC Mixer Z-Coordinate Volume Data

These cards are optional for BRANCH, SEPARATR, JETMIXER, and ECCMIX components but are not allowed for TURBINE components. These cards are used when the user specifies the z-direction connection with the crossflow model.

W1(R) Area of the volume (m^2).

W2(R) Length of the crossflow volume (m).

W3(R) Roughness.

W4(R) Hydraulic diameter (m).

W5(I) Volume control flags. This word has the general packed format tlpvbfe, but this word is limited to 00000f0 since it only enters the coordinate oriented flags for the z direction.

The digit f specifies whether wall friction is to be computed. f=0 specifies that wall friction effects are to be computed along the z coordinate direction in the volume, and f=1 specifies that wall friction effects are not to be computed along the z coordinate direction.

W6(R) This word is not used. Enter 0.

W7(R) This word is not used. Enter 0.

W8(R) This word is the position change in the z fixed (vertical) direction as the flow passes from the z inlet face to the z outlet face (m, ft). This quantity affects problems if connections are made to the zfaces.

A7.7.6 Card ccc0131, Additional Laminar Wall Friction Card

This card is optional except for a turbine component. If this card is not entered, the default values are 1.0 for the shape factor and 0.0 for the viscosity ratio exponent. Two, four, or six quantities may be entered on the card, and the data not entered are set to default values.

W1(R) Shape factor for x-coordinate.

W2(R) Viscosity ratio exponent for x-coordinate.

W3(R) Shape factor for y-coordinate.

W4(R) Viscosity ratio exponent for y-coordinate.

W5(R) Shape factor for z-coordinate.

W6(R) Viscosity ratio exponent for z-coordinate.

A7.7.7 Card ccc0200, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Volume Initial Conditions

This card is required for branch, separator, jetmixer, turbine, and ECC mixer components.

W1(I) Control word. This word has the packed format $\underline{\varepsilon}\underline{b}\underline{t}$. It is not necessary to input leading zeros.

The digit $\underline{\varepsilon}$ specifies the fluid; $\underline{\varepsilon}$=0 is the default fluid, $\underline{\varepsilon}$=1 specifies H_2O, $\underline{\varepsilon}$=2 specifies D_2O, and $\underline{\varepsilon}$=3 specifies H_2. The default fluid is that set for the hydrodynamic system by Cards 120 through 129 or this control word in another volume in this hydrodynamic system. The fluid type set on Cards 120 through 129 or these control words must be consistent (i.e., not specify different fluids). If Cards 120 through 129 are not entered and all control words use the default $\underline{\varepsilon}$=0, then water is assumed to be the fluid.

The digit $\underline{b}$ specifies whether boron is present. $\underline{b}$=0 specifies that the volume fluid does not contain boron, and $\underline{b}$=1 specifies that a boron concentration in parts of boron per parts of liquid (which may be zero) is being entered after the other required thermodynamic information.

The digit $\underline{t}$ specifies how the following words are to be used to determine the initial thermodynamic state. $\underline{t}$=0 through 3 specifies one component (steam/water); $\underline{t}$=4 through 6 allows the specification of two components (steam/water and noncondensable gas).

If $\underline{t}$=0, the next four words are interpreted as pressure (Pa, lb_f/in^2), liquid specific internal energy (J/kg, Btu/lb), vapor specific internal energy (J/kg, Btu/lb), and vapor void fraction. These quantities will be interpreted as nonequilibrium or equilibrium conditions depending on volume control flag. If equilibrium, the static quality is checked, but only the pressure and internal energies are used to define the thermodynamic state.

If t=1, the next two words are interpreted as temperature (K, ^oF) and quality in equilibrium condition.

If t=2, the next two words are interpreted as pressure (Pa, lb_f/in^2) and quality in equilibrium condition.

If t=3, the next two words are interpreted as pressure (Pa, lb_f/in^2) and temperature (K, ^oF) in equilibrium condition.

The following options are used for input of noncondensable states only. In all cases, the criteria used for determining the range of values for quality are

1.0E-9 $\leq$ quality $\leq$ 0.99999999, two phase conditions, and quality < 1.0E-9 or quality > 0.99999999, single phase.

Noncondensable options are as follows:

If t=4, the next three words are interpreted as pressure (Pa, $lb_f/in.^2$), temperature (K, ^oF), and equilibrium quality. Using this input option with quality greater than 0.0 and less than or equal to 1.0, saturated noncondensables will result. Also, the temperature is restricted to be less than the saturation temperature at the input pressure. Setting quality to 0.0 is used as a flag that will initialize the volume to all noncondensable (dry noncondensable) with no temperature restrictions. Quality is reset to 1.0 using this dry noncondensable option.

If t=5, the next three words are interpreted as temperature (K, ^oF), equilibrium quality, and noncondensable quality. Both the equilibrium and noncondensable qualities are restricted to be between 1.0E-9 and 0.99999999. Little experience has been obtained using this option, and it has not been checked out.

If t=6, the next five words are interpreted as pressure (Pa, $lb_f/in.^2$), liquid specific internal energy (J/kg, Btu/lb), vapor specific internal energy (J/kg, Btu/lb), vapor void fraction, and noncondensable quality. The combinations of vapor void fraction and noncondensable quality must be thermodynamically consistent. If noncondensable quality is set to 0.0, noncondensables are not present and the input processing branches to that type of processing. If noncondensables are present (noncondensable quality greater than 0.0), then the vapor void fraction must not be 0.0. If the noncondensable quality is set to 1.0 (pure noncondensable), then vapor void fraction must also be 1.0. When both the vapor void fraction and the noncondensable quality are set to 1.0, the volume temperature is calculated from the noncondensable energy equation using the input vapor-specific internal energy.

W2-W7(R) Quantities as described under Word 1. Depending on the control word, two through five quantities may be required. Enter only the minimum number required. If entered, boron concentration follows the last required word for thermodynamic conditions.

A7.7.8 Cards cccn101 through cccn109, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Junction Geometry Card

These cards are required if nj is greater than zero. Cards with n equal to 1 through 9 are entered, one for each junction. N equal to 1, 2, and 3 must be used for SEPARATR, JETMIXER, and ECCMIX components. For a BRANCH component, n need not be consecutive, but nj cards must be entered. The card format for Words 1 through 6 is listed below and is identical to Words1 through 6 on Card ccc0101 of the Single Junction Geometry Card, except that n instead of 0 is used in the fourth digit. Word 7 is not used for BRANCH, JETMIXER, and TURBINE components. Word 7 is defined for SEPARATR and ECCMIX components.

W1(I) From connection code to a component. This refers to the component from which the junction coordinate direction originates. For connecting to a time-dependent volume, the connection code is ccc000000, where ccc is the component number of the time-dependent volume. An old or an expanded format can be used to connect all other volumes. In the old format, use ccc000000 if the connections to the inlet side of the component and use ccc010000 if the connection is to the outlet side of the volume. In the expanded format, the connection code is cccvv000n, where ccc is the component number, vv is the volume number, and n indicates the face number. A nonzero n specifies the expanded format. The number n equal to 1 and 2 specifies the inlet and outlet faces respectively for the volume's coordinate direction (see Section 2.1). The number n equal to 3 through 6 specifies crossflow. The number n equal to 3 and 4 would specify inlet and outlet faces for the second coordinate direction; n equal to 5 and 6 would do the same for the third coordinate direction.

W2(I) To connection code to a component. This refers to the component at which the junction coordinate direction ends. See the description for W1 above.

W3(R) Junction area (m^2, ft^2). If zero, the area is set to the minimum volume area of the adjoining volumes. For abrupt area changes, the junction area must be equal to or smaller than the minimum of the adjoining volume areas. For smooth area changes, there are no restrictions.

W4(R) Forward flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is positive or zero.

W5(R) Reverse flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is negative.

W6(I) Junction control flags. This word has the packed format efvcahs.

The digit e specifies the modified PV term in the energy equations. e=0 means that the modified PV term will not be applied, and e=1 means that it will be applied. This digit is only for the BRANCH component. For the SEPARATR, JETMIXER, ECCMIX, and

TURBINE components, this digit is not used and should be set to 0. The major edit output will show e=0.

The digit f specifies CCFL options. f=0 means that the CCFL model will not be applied, and f=1 means that the CCFL model will be applied. This digit is only used for the BRANCH component. For the SEPARATR, JETMIXER, ECCMIX, and TURBINE components, the CCFL model is not allowed, this digit is not used and should be set to 0. The major edit output will show f=0.

The digit v specifies horizontal stratification entrainment/pullthrough options. This model is for junctions connected to a horizontal volume. v=0 means the model is not applied; v=1 means an upward oriented junction; v=2 means a downward oriented junction; and v=3 means a centrally (side) located junction. This digit is only used for the BRANCH component. For the SEPARATR, JETMIXER, ECCMIX, and TURBINE components, the horizontal stratification entrainment/pullthrough model is not allowed, this digit is not used and should be set to 0.

The digit c specifies choking options. c=0 means that the choking model will be applied, and c=1 means that the choking model will not be applied.

The digit a specifies area change options. a=0 means either a smooth area change or no area change, and a=1 means an abrupt area change.

The digit h specifies nonhomogeneous or homogeneous. h=0 specifies the nonhomogeneous (two-velocity momentum equations) option and h=2 specifies the homogeneous (single-velocity momentum equation) option. For the homogeneous option (h=2), the major edit printout will show h=1.

The digit s specifies momentum flux options. This digit is used for the BRANCH, SEPARATR, and TURBINE components. s=0 uses momentum flux in both the to and the from volume. s=1 uses momentum flux in the from volume, but not in the to volume. s=2 uses momentum flux in the to volume, but not in the from volume. s=3 does not use momentum flux in either the to volume or the from volume. For the JETMIXER and ECCMIX components, this digit is not used and should be input as 0.

W7(R) Void fraction limit (for SEPARATR) or ANGLE (for ECCMIX). This word is needed only for a SEPARATR or an ECCMIX component. For SEPARATR, this word is VOID FRACTION LIMIT. For the vapor exit junction (n=1), this quantity (VOVER) is the vapor void fraction above which flow out of the vapor outlet is pure vapor. If the word is missing, a default value of 0.5 is used. For the liquid fall back junction (n=2), this quantity (VUNDER) is the liquid void fraction above which flow out of the liquid fall back is pure liquid. If the word is missing, a default value of 0.15 is used. For the separator inlet, this word is not used.

For ECCMIX, this word is ANGLE and is the angle between the axis of the ECC injection line and the main pipe (or the angle between Junctions 1 and 2). This angle must be between 0 and 180 degrees. If missing, a 90-degree connection for the ECC pipe is assumed.

A7.7.9 Cards cccn110, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Junction Diameter and CCFL Data Cards

These cards are optional. The value n should follow the same approach as used in Cards cccn101-cccn109. The defaults indicated for each word are used if the card is not entered. If these cards are being used to specify only the junction hydraulic diameter for the interphase drag calculations (i.e., f=0 in Word 6 of Cards cccn101-cccn109), then the diameter should be entered in Word 1 and any allowable values should be entered in Words 2 through 4 (will not be used). If these cards are being used for the CCFL model (i.e., f=1 in Word 6 of Cards cccn101-cccn109), then enter all four words for the appropriate CCFL model if values different from the default values are desired.

W1(R) Junction hydraulic diameter, D_j (m, ft). This quantity is the junction hydraulic diameter used in the CCFL correlation equation and interphase drag. This number must be $\geq$0. This number should be computed from 4.0*(junction area)/wetted perimeter). If a zero is entered or if the default is used, the junction diameter is computed from 2.0*(junction area/π)**0.5 of the respective junction. See Word 3 of Cards cccn101-ccn109 for the junction area.

W2(R) Flooding correlation form, β. If zero, the Wallis CCFL form is used. If one, the Kutateladze CCFL form is used. f between zero and one, Bankoff weighting between the Wallis and Kutateladze CCFL forms is used. This number must be $\geq$0 and $\leq$1. The default value is 0 (Wallis form).

W3(R) Gas intercept, c. This quantity is the gas intercept used in the CCFL correlation (when $H_f^{1/2} = 0$) and must be > 0. The default value is 1.

W4(R) Slope, m. This quantity is the slope used in the CCFL correlation and must be >0. The default value is 1.

A7.7.10 Cards cccn112, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Junction Form Loss Data Card

These cards are optional. The user specified form loss is given in Words 4 and 5 of Cards cccn101-cccn109 if these cards are not entered. If these cards are entered, the form loss coefficient is calculated from

$$K_f = A_f + B_f Re^{-c_f}$$

$$K_r = A_r + B_r Re^{-c_r}$$

where K_f and K_r are the forward and reverse form loss coefficient. A_f and A_r are the Words 4 and 5 of Cards cccn101-cccn109. Re is the Reynolds number based on mixture fluid properties. If these cards are being used for the form loss calculation, then enter all four words for the appropriate expression.

W1(R) B_f ($\geq$0). This quantity must be greater than or equal to zero.

W2(R) c_f ($\geq$0). This quantity must be greater than or equal to zero.

W3(R) B_r ($\geq$0). This quantity must be greater than or equal to zero.

W4(R) c_r ($\geq$0). This quantity must be greater than or equal to zero.

A7.7.11 Cards cccn201, Branch, Separator, Jetmixer, Turbine, or ECC Mixer Junction Initial Conditions

These cards are required depending on the value of nj as described for Cards cccn101-cccn109. The values of n should follow the same approach as used in Cards cccn101-cccn109.

W1(R) Initial liquid or mass flow (velocity in m/s, ft/s or mass flow in kg/s, lb/s).

W2(R) Initial vapor velocity or mass flow (velocity in m/s, ft/s or mass flow in kg/s, lb/s).

W3(R) Interface velocity (m/s, ft/s). Enter zero.

A7.7.12 Card ccc0300, Turbine/Shaft Geometry Card

This card is used only for TURBINE components.

W1(R) Turbine stage shaft speed, w (rad/s, rev/min). This speed should equal the shaft speed used in the SHAFT component.

W2(R) Inertia of rotating stages in stage group, I_i, (kg•m^2, lb•ft^2).

W3(R) Shaft friction coefficient, f_i (N•m•s, lb•ft•s). The frictional torque equals f_ix. This fractional torque is used by the SHAFT component.

W4(I) Shaft component number to which the turbine stage is connected.

W5(I) Disconnect trip number. If zero, the turbine is always connected to the shaft. If nonzero, the turbine is connected to the shaft when the trip is false and disconnected when the trip is true.

W6(I) Drain flag. At the present time, this is not used and can be neglected or set to zero.

A7.7.13 Card ccc0400, Turbine Performance Data Card

This card is used only for TURBINE components.

W1(I) Turbine type

0 = Two-row impulse stage group.

1 = General impulse-reaction stage group.

2 = Constant efficiency stage group.

W2(R) Actual efficiency h_o at the maximum efficiency design point.

W3(R) Design reaction fraction, r. This is the fraction of the enthalpy decrease that takes place in the rotating blade system.

W4(R) Mean stage radius, r (m, ft).

A7.7.14 Card ccc0500, GE Separator Data.

This card is optional for the GE separator. If this card is missing and the GE separator has been specified on Card ccc0002, the default values will be used. If the card is present, all eight values must be specified.

W1(R) Radius of larger pickoff ring at first stage of a two-stage separator (m, ft). (Default = 0.0857208 m)

W2(R) Standpipe flow area (m^2, ft^2). (Default = 0.018637 m^2).

W3(R) Separator nozzle exit area (m^2, ft^2). (Default = 0.01441 m^2).

W4(R) Radius of separator hub at inlet (m, ft). (Default = 0.0809585 m).

W5(R) Swirl vane angle relative to the horizontal (deg). (Default = 48 deg).

W6(R) Liquid carryover coefficient for upper separating stages. (Default = 0.009 for two stage separator and 0.110 for three stage separator.)

W7(R) Vapor carryunder coefficient for upper separating stages. (Default = 0.0004).

W8(R) Axial distance between exit of first stage discharge passage and swirl vanes (m, ft). (Default = 0.2127 m for two stage separator and 0.45083 m for three stage separator.)

A7.7.15 Card ccc0501, GE Separator First Stage Data

This card is optional for the GE separator. If this card is missing and the GE separator has been specified on Card ccc0002, the default values will be used. If the card is present, all nine values must be specified.

W1(R) Liquid film void profile coefficient. (Default = 110.0.)

W2(R) Vapor core void profile coefficient. (Default = 0.5.)

W3(R) Separator wall inner radius (m, ft). (Default = 0.10794 m.)

W4(R) Pickoff ring inner radius (m, ft). (Default = 0.069875 m for two stage separator and 0.0857208 m for three stage separator.)

W5(R) Discharge passage flow area (m^2, ft^2). (Default = 0.0415776 m^2 for two stage separator and 0.0096265 m^2 for three stage separator.)

W6(R) Discharge passage hydraulic diameter (m, ft). (Default = 0.045558 m for two stage separator and 0.025399 m for three stage separator.)

W7(R) Separating barrel length (m, ft). (Default = 0.877845 m for two stage separator and 1.0699 m for three stage separator.)

W8(R) Discharge passage loss coefficient. (Default = 10.0 for two stage separator and 2.5 for three stage separator.)

W9(R) Discharge passage effective L/D coefficient. (Default = 450.0 for two stage separator and 53.44 for three stage separator.)

A7.7.16 Card ccc0502, GE Separator Second Stage Data

This card is optional for the GE separator. If this card is missing and the GE separator has been specified on Card ccc0002, the default values will be used. If the card is present, all nine values must be specified.

W1(R) Liquid film void profile coefficient. (Default = 20.0.)

W2(R) Vapor core void profile coefficient. (Default = 0.25.)

W3(R) Separator wall inner radius (m, ft). (Default = 0.06985 m for two-stage separator and 0.10794 m for three-stage separator.)

W4(R) Pickoff ring inner radius (m, ft). (Default = 0.06032 m for two-stage separator and 0.0952453 m for three-stage separator.)

W5(R) Discharge passage flow area (m^2, ft^2). (Default = 0.0029133 m^2 for two-stage separator and 0.0096265 m^2 for three-stage separator.)

W6(R) Discharge passage hydraulic diameter (m, ft). (Default = 0.0121699 m for two-stage separator and 0.025399 m for three-stage separator.)

W7(R) Separating barrel length (m, ft). (Default = 0.16255 m for two-stage separator and 0.384156 m for three-stage separator.)

W8(R) Discharge passage loss coefficient. (Default = 0.5 for two-stage separator and 1.429 for three-stage separator.)

W9(R) Discharge passage effective L/D coefficient. (Default = 95.85 for two-stage separator and 194.64 for three-stage separator.)

A7.7.17 Card ccc0503, GE Separator Third Stage Data

This card is optional for the GE separator. If this card is missing and the GE three-stage separator has been specified on Card ccc0002, the default values will be used. If the card is present, all nine values must be specified.

W1(R) Liquid film void profile coefficient. (Default = 20.0.)

W2(R) Vapor core void profile coefficient. (Default = 0.55.)

W3(R) Separator wall inner radius (m, ft). (Default = 0.10794 m.)

W4(R) Pickoff ring inner radius (m, ft). (Default = 0.0984201 m.)

W5(R) Discharge passage flow area (m^2, ft^2). (Default = 0.0096265 m^2.)

W6(R) Discharge passage hydraulic diameter (m, ft). (Default = 0.025399 m.)

W7(R) Separating barrel length (m, ft). (Default = 0.384156 m.)

W8(R) Discharge passage loss coefficient. (Default = 2.563.)

W9(R) Discharge passage effective L/D coefficient. (Default = 424.96.)

A7.7.18 Card ccc0600, GE Dryer Data

This card is optional for the GE dryer. If this card is missing and the GE dryer has been specified on Card ccc0002, the default values will be used. If the card is present, all three values must be specified.

W1(R) Vapor velocity at dryer inlet below which there is 0% liquid carryover (m/s, ft/s). (Default = 1.5 m/s.)

W2(R) Vapor velocity at dryer inlet above which there is 100% liquid carryover (m/s, ft/s). (Default = 6.0 m/s.)

W3(R) Range of dryer inlet quality where dryer carryover changes from 0 to 100% when dryer inlet vapor velocity is between lower and upper values. (Default = 0.05.)

A7.8 Valve Junction Component

A valve junction component is indicated by VALVE on Card ccc0000. For major edits, minor edits, and plot variables, the junction in the valve junction component is numbered ccc000000.

A7.8.1 Cards ccc0101 through ccc0109, Valve Junction Geometry Cards

This card (or cards) is required for valve junction components.

W1(I) From connection code to a component. This refers to the component from which the junction coordinate direction originates. For connecting to a time-dependent volume, the connection code is ccc000000, where ccc is the component number of the time-dependent volume. An old or an expanded format can be used to connect all other volumes. In the old format, use ccc000000 if the connection is to the inlet side of the component and use ccc010000 if the connection is to the outlet side of the volume. In the expanded format, the connection code is cccvv000n, where ccc is the component number, vv is the volume number, and n indicates the face number. A nonzero n specifies the expanded format. The number n equal to 1 and 2 specifies the inlet and outlet faces respectively for the volume's coordinate direction (see Section 2.1). The number n equal to 3 through 6 specifies crossflow. The number n equal to 3 and 4 would specify inlet and outlet faces for the second coordinate direction; n equal to 5 and 6 would do the same for the third coordinate direction.

W2(I) To connection code to a component. This refers to the component at which the junction coordinate direction ends. See the description for W1 above.

W3(R) Junction area (m^2, ft^2). This quantity is the full open area of the valve except in the case of a relief valve. For valves other than relief valves, if this area is input as zero, the area is set to the minimum area of adjoining volumes. If nonzero, this area is used. For relief valves, this term is the valve inlet throat area. If this term is input as zero, it will default to the area calculated from the inlet diameter term input on Cards ccc0301 through ccc0309, in which case the inlet diameter term cannot be input as zero. If both this area and the inlet diameter are input as nonzero, this area will be used but must agree with the area calculated from the inlet diameter within 10^{-5} m^2. However, if this area is input as nonzero and the inlet diameter is input as zero, the inlet diameter will default to the diameter calculated from this area. When an abrupt area change model is specified, the area must be less than or equal to the minimum of the adjoining volume areas.

W4(R) Forward flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is positive or zero.

W5(R) Reverse flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is negative.

W6(I) Junction control flags. This word has the packed format efvcahs. It is not necessary to input leading zeros.

The digit e specifies the modified PV term in the energy equations. e=0 means that the modified PV term will not be applied, and e=1 means that it will be applied.

The digit f specifies CCFL options. f=0 means that the CCFL model will not be applied, and f=1 means that the CCFL model will be applied.

The digit v is not used and should be input as zero (v=0). The horizontal stratification/ entrainment model is not used.

The digit c specifies choking options. c=0 means that the choking model will be applied, and c=1 means that the choking model will not be applied.

The digit a specifies area change options. a=0 means either a smooth area change or no area change, and a=1 means an abrupt area change. Either option may be input for a motor or servo valve. If the smooth area change option is input, then a C_v table must be input; or, if no C_v table is input, then the abrupt area change option must be input. For all other valves, the abrupt area change option must be input.

The digit h specifies nonhomogeneous or homogeneous. h=0 specifies the nonhomogeneous (two-velocity momentum equations) option; h=2 specifies the homogeneous (single-velocity momentum equation) option. For the homogeneous option (h=2), the major edit printout will show h=1.

The digit s is not used and should be input as zero (s=0). The major edit printout will show s=0.

W7(R) Subcooled discharge coefficient. This quantity is applied only to subcooled choked flow calculations. The quantity must be >0 and ≤2.0. If missing, it is set to 1.0.

W8(R) Two phase discharge coefficient. This quantity is applied only to two-phase choked flow calculations. The quantity must be >0 or ≤2.0. If missing, it is set to 1.0.

W9(R) Superheated discharge coefficient. This quantity is applied only to superheated choked flow calculations. The quantity must be >0 and ≤2.0. If missing, it is set to 1.0.

A7.8.2 Card ccc0110, Valve Junction Diameter and CCFL Data Card

This card is optional. The defaults indicated for each word are used if the card is not entered. If this card is being used to specify the junction hydraulic diameter for the interphase drag calculation (i.e., f=0 in Word 6 of Cards ccc0101-ccc0109), then the diameter should be entered in Word 1 and any allowable values should be entered in Words 2 through (will not be used). If this card is being used for the CCFL model (i.e., f=1 in Word 6 of Cards ccc0101-ccc0109), then enter all four words for the appropriate CCFL model if values different from the default values are used.

W1(R) Junction hydraulic diameter, D_j (m, ft). This is the junction hydraulic diameter used in the CCFL correlation equation and interphase drag and must be ≥0. This number should be computed from 4.0*(junction area)/(wetted perimeter). If a zero is entered or if the default is used, the junction diameter is computed from 2.0* (junction area/π)**0.5. See Word 3 of Cards ccc0101-ccc0109 for the junction area.

W2(R) Flooding correlation form, β. If zero, the Wallis CCFL form is used. If one, the Kutateladze CCFL form is used. If between zero and one, Bankoff weighting between the Wallis and Kutateladze CCFL forms is used. This number must be ≥0 and≤ 1. The default value is 0 (Wallis form).

W3(R) Gas intercept, c. This is the gas intercept used in the CCFL correlation (when $H_f^{1/2} = 0$) and must be >0. The default value is 1.

W4(R) Slope, m. This is the slope used in the CCFL correlation and must be >0. The default value is 1.

A7.8.3 Card ccc0111, Valve Junction Form Loss Data Card

This card is optional. The user specified form loss is given in Words 4 and 5 of Card ccc0101 if this card is not entered. If this card is entered, the form loss coefficient is calculated from

$$K_f = A_f + B_f Re^{-c_f}$$

$$K_r = A_r + B_r Re^{-c_r}$$

where K_f and K_r are the forward and reverse form loss coefficient. A_f and A_r are the Words 4 and 5 of Card ccc0101. Re is the Reynolds number based on mixture fluid properties. If this card is being used for the form loss calculation, then enter all four words for the appropriate expression.

W1(R) B_f (≥ 0). This quantity must be greater than or equal to zero.

W2(R) c_f (≥ 0). This quantity must be greater than or equal to zero.

W3(R) B_r (≥ 0). This quantity must be greater than or equal to zero.

W4(R) c_r (≥ 0). This quantity must be greater than or equal to zero.

A7.8.4 Card ccc0201, Valve Junction Initial Conditions

This card is required for valve junction components.

W1(I) Control word. If zero, the next two words are velocities; if one, the next two words are mass flows.

W2(R) Initial liquid velocity or mass flow. This quantity is either velocity (m/s, ft/s) or mass flow (kg/s, lb/s), depending on the control word.

W3(R) Initial vapor velocity or mass flow. This quantity is either velocity (m/s, ft/s) or mass flow (kg/s, lb/s), depending on the control word.

W4(R) Interface velocity (m/s, ft/s). Enter zero.

A7.8.5 Card ccc0300, Valve Type Card

This card is required to specify the valve type.

W1(A) Valve type. This word must contain one of the following: CHKVLV for a check valve, TRPVLV for a trip valve, INRVLV for an inertial swing check valve, MTRVLV for a motor valve, SRVVLV for a servo valve, or RLFVLV for a relief valve.

A7.8.6 Cards ccc0301 through ccc0399, Valve Data and Initial Conditions

These cards are required for valve junction components. Six different types of valves are allowed. The following words may be placed on one or more cards, and the card numbers need not be consecutive. The card format of these cards depends on the valve type.

A7.8.6.1 Check Valve. This behaves as an on, off switch. If the valve is on, then it is fully open; and if the valve is off, it is fully closed.

W1(I) Check valve type. Enter +1 for a static pressure-controlled check valve (no hysteresis), 0 for a static pressure/flow-controlled check valve (has hysteresis effect), or -1 for a static/dynamic pressure-controlled check valve (has hysteresis effect). It is recommended that 0 be used for most calculations, as it is more stable (i.e., less noisy and less oscillations) than +1 or -1.

W2(I) Check valve initial position. The valve is initially open if zero, closed if one.

W3(R) Closing back pressure (Pa, lb_f/in^2).

W4(R) Leak ratio. This is the fraction of the junction area for the leakage when the valve is nominally closed. If omitted or input as zero, then either the smooth or the abrupt area change model may be specified. If input as nonzero, then the abrupt area change model must be specified.

A7.8.6.2 Trip Valve. This behaves as an on, off switch as described for the check valve.

W1(I) Trip number. This must be a valid trip number. If the trip is false, the valve is closed; if the trip is true, the valve is open.

A7.8.6.3 Inertial Valve. This behaves realistically in that the valve area varies considering the hydrodynamic forces and the flapper inertia, momentum, and angular acceleration. The abrupt area change model must be specified.

W1(I) Latch option. The valve can open and close repeatedly if the latch option is zero. The valve either opens or closes only once if the latch option is one.

W2(I) Valve initial condition. The valve is initially open if zero, initially closed if one.

W3(R) Cracking pressure (Pa, lb_f/in^2).

W4(R) Leakage fraction. Fraction of the junction area for leakage when the valve is nominally closed.

W5(R) Initial flapper angle (degrees). The flapper angle must be within the minimum and maximum angles specified in Words 6 and 7.

W6(R) Minimum flapper angle (degrees). This must be greater than or equal to zero.

W7(R) Maximum flapper angle (degrees).

W8(R) Moment of inertia of valve flapper ($kg \cdot m^2$, $lb \cdot ft^2$).

W9(R) Initial angular velocity (rad/s).

W10(R) Moment length of flapper (m, ft).

W11(R) Radius of flapper (m, ft).

W12(R) Mass of flapper (kg, lb).

A7.8.6.4 Motor Valve. This behaves realistically in that the valve area varies as a function of time by either of two models specified by the user. The user must also select the model for valve hydrodynamic losses by specifying either the smooth or the abrupt area change model. If the smooth area change model is selected, a table of flow coefficients must also be input as described in Cards ccc0400 through ccc0499, CSUBV Table Section A7.8.7. If the abrupt area change model is selected, a flow coefficient table cannot be input.

W1(I) Open trip number.

W2(I) Close trip number. Both the open and close trip numbers must be valid trips. When both trips are false, the valve remains at its current position. When one of the trips is true, the valve opens or closes depending on which trip is true. The transient will be terminated if both trips are true at the same time.

W3(R) Valve change rate (s^{-1}). If Word 5 is not entered, this quantity is the rate of change of the normalized valve area as the valve opens or closes. If Word 5 is entered, this quantity is the rate of change of the normalized valve stem position. This word must be greater than zero.

W4(R) Initial position. This number is the initial normalized valve area or the initial normalized stem position depending on Word W5. This quantity must be between 0.0 and 1.0.

W5(I) Valve table number. If this word is omitted or input as zero, the valve area is determined by the valve change rate and the trips. If this word is input as nonzero, the valve stem position is determined by the valve change rate and the trips; and the valve area is determined from a general table containing normalized valve area versus normalized stem position.

Input for general tables is discussed in Cards 202tttnn, General Table Data, Section A11. For this case, the normalized stem position is input as the *argument value* and the normalized valve area is input as the *function value*.

A7.8.6.5 Servo Valve. This behaves as described for a motor valve except that the valve flow area or stem position is calculated by a control system. Input for control systems is discussed in Section A1. Input specifying the hydrodynamic losses for servo valves is also identical to that for motor valves.

W1(I) Control variable number. The value of the indicated control variable is either the normalized valve area or the normalized stem position, depending on whether Word 2 is entered. The control variable is also the search argument for the CSUBV table if it is entered.

W2(I) Valve table number. If this word is not entered, the control variable value is the normalized flow area. If it is entered, the control variable value is the normalized stem position, and the general table indicated by this word contains a table of normalized area versus normalized stem position. Input for the general table is identical to that for a motor valve.

A7.8.6.6 Relief Valve. The valve area varies, considering the hydrodynamic forces and the valve mass, momentum, and acceleration. The abrupt area change model must be specified. The junction area input by Card ccc0101 through ccc0199 is the valve inlet area.

W1(I) Valve initial condition. The valve is initially closed if zero, open if one.

W2(R) Inlet diameter (m, ft). This is the inside diameter of the valve inlet. If this term is input as zero, it will default to the diameter calculated from the junction area input on Card ccc0101 through ccc0109. If both this diameter and the junction area are input as nonzero, care must be taken that these terms are input with enough significant digits so that the areas agree within 10^{-5} m^2. If the junction area is input as zero, then this diameter must be input as nonzero.

W3(R) Valve seat diameter (m, ft). Nonzero input is required. This term is the outside diameter of the valve seat, including the minimum diameter of the inner adjustment ring. This term must also be greater than or equal to the inlet diameter.

W4(R) Valve piston diameter (m, ft). If input as zero, the default is to the valve seat diameter.

W5(R) Valve lift (m, ft). Nonzero input is required. This is the distance the valve piston rises above the valve seat at the fully open position.

W6(R) Maximum outside diameter of the inner adjustment ring (m, ft). If this input is zero, it will default to the valve seat diameter; in which case W7(R), following, must be input as zero. If this input is nonzero, the value must be greater than or equal to the valve seat diameter. If input is greater than the valve seat diameter, a nonzero input of W7(R), is allowed. Also refer to the warning stated for W9(R).

W7(R) Height of outside shoulder relative to the valve seat for inner adjustment ring (m, ft). Input of a positive, nonzero value is not allowed. Input of a zero value is required if W6(R) preceding is defaulted or input equal to the valve seat diameter. If the shoulder is below the seat, this distance is negative. Also refer to the warning stated for W9(R).

W8(R) Minimum inside diameter of the outer adjustment ring (m, ft). If this input is zero, it will default to the valve piston diameter, in which case W9(R) must be input as positive and nonzero. If this input is nonzero, the value must be greater than or equal to the valve piston diameter. Input of a negative W9(R) is allowed only if this diameter is greater than the valve piston diameter. Also refer to the warning stated for W9(R).

W9(R) Height of inside bottom edge relative to the valve seat for outer adjustment ring (m, ft). This may be input as positive, zero, or negative. If this input is negative, then W8(R) preceding must be greater than the valve piston diameter. If the bottom edge is below the valve seat, this distance is negative. WARNING: Input of this term and terms W6(R), W7(R), and W8(R) preceding must be done with care to ensure that the resultant gap between the adjustment rings is positive and nonzero; otherwise, an input error will result.

W10(R) Bellows average diameter (m, ft). If this term is input as zero, it will default to the valve piston diameter, resulting in a model not containing a bellows for which the valve bonnet region is vented to the atmosphere.

W11(R) Valve spring constant (N/m, lb_f/ft). Positive, nonzero input is required.

W12(R) Valve setpoint pressure (Pa, lb_f/in^2). Positive input is required.

W13(R) Valve piston, rod, spring, bellows mass (kg, lb). Nonzero input is required.

W14(R) Valve damping coefficient ($N \times s$/m, $lb_f \times s$/ft).

W15(R) Bellows inside pressure (Pa, lb_f/in^2). Defaults to standard atmospheric pressure if omitted or input as zero.

W16(R) Initial stem position. This is the fraction of total lift and is required if W1(I) is input as one. Total lift is input as W5(R).

W17(R) Initial valve piston velocity (m/s, ft/s). This must be zero or omitted if W1(I) is input as zero.

A7.8.7 Cards ccc0400 through ccc0499, Valve CSUBV Table

The CSUBV table may be input only for motor and servo valves. If the CSUBV table is input, the smooth area change model must be specified on the valve junction geometry card (Card ccc0101 through ccc0109). If the smooth area change model is specified, a CSUBV table must be input.

The CSUBV table contains forward and reverse flow coefficients as a function of normalized flow area or normalized stem position.

A7.8.7.1 Cards ccc0400, Factors. This card is optional. The factors apply to the flow area or the stem position and the flow coefficient entries in the CSUBV table.

W1(R) Normalized flow area or normalized stem position.

W2(R) Flow coefficient factor.

A7.8.7.2 Cards ccc0401 through ccc0499, Table Entries. The table is entered by using three-word sets. W1 is the flow area or stem position and must be normalized. The factor W1 on Card ccc0400 can be used to normalize the flow area or stem position. In either case, the implication is that if the valve is fully closed, the normalized term is zero. If the valve is fully open, the normalized term is one. Any value may be input that is between zero and one. The forward and reverse flow coefficients are W2 and W3, respectively. The code internally converts flow coefficients to energy loss coefficients by the formula K = 2*A_j**2/(ρ*CSUBV**2), where ρ is density of water at 60 ^{o}F (288.71 K), A_j is the full open valve area, and CSUBV is the flow coefficient. On Card ccc0400, W2 may be used to modify the definition of CSUBV. A smooth area change must be specified in W6 on Card ccc0101 to use the CSUBV table. CSUBV is entered in British units only.

W1(R) Normalized flow area or normalized stem position.

W2(R) Forward CSUBV {gal/[min×(lb_f/in^2)**0.5]}. The CSUBV is input in British units only and is converted to SI units using 7.598055E-7 as the conversion factor.

W3(R) Reverse CSUBV {gal/[min×(lb_f/in^2)**0.5]}.

A7.9 Pump Component

A pump component is indicated by PUMP on Card ccc0000. A pump consists of one volume and two junctions, one attached to each end of the volume. For major edits, minor edits, and plot variables, the volume in the pump component is numbered as ccc010000. The pump junctions are numbered ccc010000 for the inlet junction and ccc020000 for the outlet junction.

A7.9.1 Cards ccc0101 through ccc0107, Pump Volume Geometry Cards

This card (or cards) is required for a pump component. The seven words can be entered on one or more cards, and the card numbers need not be consecutive.

W1(R) Volume flow area (m^2, ft^2).

W2(R) Length of volume (m, ft).

W3(R) Volume of volume (m^3, ft^3). The program requires that the volume equals the volume flow area times the length (W3=W1*W2). At least two of the three quantities, W1, W2, W3, must be nonzero. If one of the quantities is zero, it will be computed from the other two. If none of the words are zero, the volume must equal the area times the length within a relative error of 0.000001.

W4(R) Azimuthal angle (degrees). The absolute value of this angle must be ≤360 degrees. This quantity is not used in the calculation but is specified for possible automated drawing of nodalization diagrams.

W5(R) Inclination angle (degrees). The absolute value of this angle must be ≤90 degrees. The angle 0 degrees is horizontal, and positive angles have an upward direction, i.e., the outlet is at a higher elevation than the inlet. This angle is used in the interphase drag calculation.

W6(R) Elevation change (m, ft). A positive value is an increase in elevation. The absolute value of this quantity must be equal to or less than the volume length. If the vertical angle orientation is zero, this quantity must be zero. If the vertical angle is nonzero, this quantity must also be nonzero and have the same sign. For this component, this Word 6 is not compared to the volume length (Word 2) to decide if the horizontal or vertical flow regime is used. Rather, the pump flow regime map is used.

W7(I) Volume control flags. This word has the packed format tlpvbfe. It is not necessary to input leading zeros. Volume flags consist of scaler oriented and coordinate direction oriented flags. Only one value for a scaler oriented flag is entered per volume but up to three coordinate oriented flags can be entered for a volume, one for each coordinate direction. At present, the f flag is the only coordinate direction oriented flag. This word enters the scaler oriented flags and the x coordinate flag. The pump component forces all volume flags except for the e digit, and y and z coordinate flags are not read. The effective format is 000000e.

The digit t is not used and must be input as zero (t=0). Thermal stratification is not used in a pump component.

The digit l is not used and must be entered as zero (l=0). Level tracking is not used in a pump component.

The digit p is not used and must be input as zero (p=0). The major edit output will show p=1. The water packing scheme is not used.

The digit v is not used and must be input as zero (v=0). The major edit output will show v=1. The vertical stratification model is not used.

The digit b is not used and must be input as zero (b=0). The major edit will show b=0. The rod bundle interphase friction is not used.

The digit f that normally specifies whether wall friction is to be computed is not used and a 0 must be entered. No wall friction is computed for a pump, since it is included in the homologous pump data. The major edit output will show f=1, which indicates that the no friction flag is set.

The digit e specifies if nonequilibrium or equilibrium is to be used; e=0 specifies that a nonequilibrium (unequal temperature) calculation is to be used, and e=1 specifies that an equilibrium (equal temperature) calculation is to be used. Equilibrium volumes should not be connected to nonequilibrium volumes. The equilibrium option is provided only for comparison to other codes.

A7.9.2 Card ccc0108, Pump Inlet (Suction) Junction Card

This card is required for a pump component.

W1(I) Volume code of connecting volume on inlet side. This refers to the component from which the junction coordinate direction originates. For connecting to a time-dependent volume, the connection code is ccc000000, where ccc is the component number of the time dependent volume. An old or an expanded format can be used to connect all other volumes. In the old format, use ccc000000 if the connection is to the inlet side of the component and use ccc010000 if the connection is to the outlet side of the volume. In the expanded format, the connection code is cccvv000n, where ccc is the component number, vv is the volume number, and n indicates the face number. A nonzero n specifies the expanded format. The number n equal to 1 and 2 specifies the inlet and outlet faces respectively for the volume's coordinate direction (see Section 2.1). The number n equal to 3 through 6 specifies crossflow. The number n equal to 3 and 4 would specify inlet and outlet faces for the second coordinate direction; n equal to 5 and 6 would do the same for the third coordinate direction.

With the old format, connections are possible only to the inlet or crossflow faces of the first pipe volume or to the outlet or crossflow faces of the last pipe volume. With the expanded format, connections can be made to any face of any pipe volume. Output edits use the expanded format regardless of the input format.

W2(R) Junction area (m^2, ft^2). If zero, the area is set to the minimum of the volume areas of adjacent volumes. If an abrupt area change, the area must be equal to or less than the minimum of the adjacent volume areas. If a smooth area change, no restrictions exist. Note: a variable loss coefficient may be specified. See Section A7.9.6.

W3(R) Forward flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is positive or zero. Note: a variable loss coefficient may be specified. See Section A7.9.6.

W4(R) Reverse flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is negative.

W5(I) Junction control flags. This word has the packed format efvcahs. It is not necessary to input leading zeros.

The digit e is not used and should be input as zero (e=0).

The digit f specifies CCFL options. f=0 means that the CCFL model will not be applied, and f=1 means that the CCFL model will be applied.

The digit v is not used and should be input as zero (v=0). The horizontal stratification entrainment/pullthrough model is not used.

The digit c specifies choking options. c=0 means that the choking model will be applied, and c=1 means that the choking model will not be applied.

The digit a specifies area change options. a=0 means either a smooth area change or no area change, and a=1 means an abrupt area change.

The digit h specifies nonhomogeneous or homogeneous. h=0 specifies the nonhomogeneous (two-velocity momentum equations) option; h=2 specifies the homogeneous (single-velocity momentum equation) option. For the homogeneous option (h=2), the major edit printout will show a one.

The digit s is not used and should be input as zero (s=0).

A7.9.3 Card ccc0109, Pump Outlet (Discharge) Junction Card

This card is required for a pump component. The format for this card is identical to Card ccc0108 except data are for the outlet junction.

A7.9.4 Card ccc0110, Pump Inlet (Suction) Junction Diameter and CCFL Data Card

This card is optional. The defaults indicated for each word are used if the card is not entered. If this card is being used to specify only the junction hydraulic diameter for the interphase drag calculation (i.e., f=0 in Word 5 of Card ccc0108), then the diameter should be entered in Word 1 and any allowable values should be entered in Words 2 through 4 (will not be used). If the card is being used for the CCFL model (i.e., f=1 in Word 5 of card ccc0108), then enter all four words for the appropriate CCFL model if values different from the default values are desired.

W1(R) Junction hydraulic diameter, D_j (m, ft). This is the junction hydraulic diameter used in the CCFL correlation equation and interphase drag and must be $\geq$0. This number should be computed from 4.0*(junction area)/(wetted perimeter). If a zero is entered or the default is used, the junction diameter is computed from 2.0*(junction area/π)**0.5. See Word 2 of Card ccc0108 for the junction area.

W2(R) Flooding correlation form, β. If zero, the Wallis CCFL form is used. If one, the Kutateladze CCFL form is used. If between zero and one, Bankoff weighting between the Wallis and Kutateladze CCFL forms is used. This number must be $\geq$0 and $\leq$1. The default value is 0 (Wallis form).

W3(R) Gas intercept, c. This is the gas intercept used in the CCFL correlation (when $H_f^{1/2} = 0$) and must be > 0. The default value is 1.

W4(R) Slope, m. This is the slope used in the CCFL correlation and must be >0. The default value is 1.

A7.9.5 Card ccc0111, Pump Outlet (Discharge) Junction Diameter and CCFL Data Card

This card is optional. The defaults indicated for each word are used if the card is not entered. If this card is being used to just specify the junction hydraulic diameter for the interphase drag calculation (i.e., f=0 in Word 5 of Card ccc0109), then the diameter should be entered in Word 2 and any allowable values should be entered in Words 2 through 4 (will not be used). If the card is being used for the CCFL model (i.e., f=1 in Word 5 of Card ccc0109), then enter all four words for the appropriate CCFL model if values different from the default values are desired. The format for this card is identical to Card ccc0110 except that data are for the outlet junction.

A7.9.6 Card ccc0112, Pump Inlet (Suction) Junction Form Loss Data Card

This card is optional. The user-specified form loss is given in Words 3 and 4 of Card ccc0108 if this card is not entered. If this card is entered, the form loss coefficient is calculated from

$$K_f = A_f + B_f Re^{-c_f}$$

$$K_r = A_r + B_r Re^{-c_r}$$

where K_f and K_r are the forward and reverse form loss coefficient. A_f and A_r are the Words 3 and 4 of Card ccc0108. Re is the Reynolds number based on mixture fluid properties. If this card is being used for the form loss calculation, then enter all four words for the appropriate expression.

W1(R) B_f ($\geq$0). This quantity must be greater than or equal to zero.

W2(R) c_f ($\geq$0). This quantity must be greater than or equal to zero.

W3(R) B_r ($\geq$0). This quantity must be greater than or equal to zero.

W4(R) c_r ($\geq$0). This quantity must be greater than or equal to zero.

A7.9.7 Card ccc0113, Pump Outlet (Discharge) Junction Form Loss Data Card

This card is optional. The user-specified form loss is given in Words 3 and 4 of Card ccc0109 if this card is not entered. If this card is entered, the form loss coefficient is calculated from

$$K_f = A_f + B_f Re^{-c_f}$$

$$K_r = A_r + B_r Re^{-c_r}$$

where K_f and K_r are the forward and reverse form loss coefficient. A_f and A_r are the Words 3 and 4 of Card ccc0109. Re is the Reynolds number based on mixture fluid properties. If this card is being used for the form loss calculation, then enter all four words for the appropriate expression. The format of this card is identical to Card ccc0112 except data are for the outlet junction.

A7.9.8 Card ccc0200, Pump Volume Initial Conditions

This card is required for a pump component.

W1(I) Control word. This word has the packed format $\underline{\varepsilon bt}$. It is not necessary to input leading zeros.

The digit $\underline{\varepsilon}$ specifies the fluid; $\underline{\varepsilon}$=0 is the default fluid, $\underline{\varepsilon}$=1 specifies H_2O, $\underline{\varepsilon}$=2 specifies D_20, and $\underline{\varepsilon}$=3 specifies H_2. The default fluid is that set for the hydrodynamic system by Cards 120 through 129 or this control word in another volume in this hydrodynamic system. The fluid type set on Cards 120 through 129 or these control words must be consistent (i.e., not specify different fluids). If cards 120 through 129 are not entered and all control words use the default $\underline{\varepsilon}$=0, then H_2o is assumed to be the fluid.

The digit b specifies whether boron is present. b=0 specifies that the volume fluid does not contain boron; b=1 specifies that a boron concentration in parts of boron per parts of liquid (which may be zero) is being entered after the other required thermodynamic information

The digit t specifies how the following words are to be used to determine the initial thermodynamic state. t=0 through 3 specifies one component (steam/water). Entering t=4 through 6 allows the specification of two components (steam/water and noncondensable gas).

If t=0, the next four words are interpreted as pressure (Pa, lb_f/in^2), liquid specific internal energy (J/kg, Btu/lb), vapor specific internal energy (J/kg, Btu/lb), and vapor void fraction. These quantities will be interpreted as nonequilibrium or equilibrium conditions depending on volume control flag. If equilibrium, the static quality is checked, but only the pressure and internal energies are used to define the thermodynamic state.

If t=1, the next two words are interpreted as temperature (K, ^oF) and quality in equilibrium condition.

If t=2, the next two words are interpreted as pressure (Pa, lb_f/in^2) and quality in equilibrium condition.

If t=3, the next two words are interpreted as pressure (Pa, lb_f/in^2) and temperature (K, ^oF) in equilibrium condition.

The following options are used for input of noncondensable states only. In all cases, the criteria used for determining the range of values for quality are

1.0E-9 $\leq$ quality $\leq$ 0.99999999, two phase conditions, and quality < 1.0E-9 or quality > 0.99999999, single phase.

Noncondensable options are as follows:

If t=4, the next three words are interpreted as pressure (Pa, $lb_f/in.^2$), temperature (K, ^oF), and equilibrium quality.

Using this input option with quality >0.0 and $\leq$1.0, saturated noncondensables will result. Also, the temperature is restricted to be less than the saturation temperature at the input pressure.

Setting quality to 0.0 is used as a flag that will initialize the volume to all noncondensables (dry noncondensable) with no temperature restrictions. Quality is reset to 1.0 using this dry noncondensable option.

If t=5, the next three words are interpreted as temperature (K, ^oF), equilibrium quality, and noncondensable quality. Both the equilibrium and noncondensable qualities are restricted to be between 1.0E-9 and 0.99999999. Little experience has been obtained using this option, and it has not been checked out.

If t=6, the next five words are interpreted as pressure (Pa, $lb_f/in.^2$), liquid specific internal energy (J/kg, Btu/lb), vapor specific internal energy (J/kg, But/lab), vapor void fraction, and noncondensable quality. The combinations of vapor void fraction and noncondensable quality must be thermodynamically consistent. If noncondensable quality is set to 0.0, noncondensables are not present and the input processing branches to that type of processing. If noncondensables are present (noncondensable quality greater than 0.0), then the vapor void fraction must not be 0.0. If the noncondensable quality is set to 1.0 (pure noncondensable), then vapor void fraction must also be 1.0. When both the vapor void fraction and the noncondensable quality are set to 1.0, the volume temperature is calculated from the noncondensable energy equation using the input vapor-specific internal energy.

W2-W7(R) Quantities as described under word 1. Depending on the control word, two through five quantities may be required. Enter only the minimum number required. If entered, boron concentration follows the last required word for thermodynamic conditions.

A7.9.9 Card ccc0201, Pump Inlet (Suction) Junction Initial Conditions

This card is required for a pump component.

W1(I) Control word. If zero, the next two words are velocities; if one, the next two words are mass flow rates.

W2(R) Initial liquid velocity or mass flow. This quantity is either velocity (m/s, ft/s) or mass flow (kg/s, lb/s).

W3(R) Initial vapor velocity or mass flow. This quantity is either velocity (m/s, ft/s) or mass flow (kg/s, lb/s).

W4(R) Initial interface velocity (m/s, ft/s). Enter zero.

A7.9.10 Card ccc0202, Pump Outlet (Discharge) Junction Initial Conditions

This card is similar to Card ccc0201 except that data are for the outlet junction.

A7.9.11 Card ccc0301, Pump Index and Option Card

This card is required for a pump component.

W1(I) Pump table data indicator. If zero, single phase homologous tables are entered with this component. A positive nonzero number indicates that the single phase tables are to be obtained from the pump component with this number. If -1, use built-in data for the Bingham pump. If -2, use built-in data for the Westinghouse pump.

W2(I) Two phase index. Enter -1 if the two phase option is not to be used. Enter zero if the two phase option is desired and two phase multiplier tables are entered with this component. Enter nonzero if the two phase option is desired and the two phase multiplier table data are to be obtained from the pump component with the number entered. There are no built-in data for the two phase multiplier table.

W3(I) Two phase difference table index. Enter -3 if the two phase difference table is not needed (i.e., if W2 is -1). Enter zero if a table is entered with this component. Enter a positive nonzero number if the table is to be obtained from pump component with this number. Enter -1 for built-in data for the Bingham pump. Enter -2 for built-in data for the Westinghouse pump.

W4(I) Pump motor torque table index. If -1, no table is used. If zero, a table is entered for this component. If nonzero, use the table from the component with this number.

W5(I) Time dependent pump velocity index. If -1, no time-dependent pump rotational velocity table is used and the pump velocity is always determined by the torque-inertia equation. If zero, a table is entered with this component. If nonzero, the table from the pump component with this number is used. A pump velocity table cannot be used when the pump is connected to a shaft control component.

W6(I) Pump trip number. When the trip is off, electrical power is supplied to the pump motor; when the trip is on, electrical power is disconnected from the pump motor. The pump velocity depends on the pump velocity table and associated trip, the pump motor torque data, and this trip. If the pump velocity table is being used, the pump velocity is always computed from that table. If the pump velocity table is not being used, the pump velocity depends on the pump motor torque data and this trip. If the trip is off and no pump motor torque data are present, the pump velocity is the same as for the previous time step. This will be the initial pump velocity if the pump trip has never been set. Usually the pump trip is a latched trip, but that is not necessary. If the trip is off and a pump motor torque table is present, the pump velocity is given by the torque-inertia equation where the net torque is given by the pump motor torque data and the homologous torque data. If the trip is on, the torque-inertia equation is used and the pump motor torque is set to zero. If the pump trip number is zero, no trip is tested and the pump trip is assumed to always be off.

W7(I) Reverse indicator. If zero, no reverse is allowed; if one, reverse is allowed.

A7.9.12 Cards ccc0302 through ccc0304, Pump Description Card

This card (or cards) is required for a pump component.

W1(R) Rated pump velocity (rad/s, rev/min).

W2(R) Ratio of initial pump velocity to rated pump velocity. Used for calculating initial pump velocity.

W3(R) Rated flow (m^3/s, gal/min).

W4(R) Rated head (m, ft).

W5(R) Rated torque (N•m, lb_f•ft).

W6(R) Moment of inertia ($kg{\bullet}m^2$, $lb{\bullet}ft^2$). This includes all direct coupled rotating components, including the master for a motor driven pump.

W7(R) Rated density (kg/m^3, lb/ft^3). If zero, initial density is used. This is the density used to generate homologous data.

W8(R) Rated pump motor torque ($N{\bullet}m$, $lb_f{\bullet}ft$). If this word is zero, the rated pump motor torque is computed from the initial pump velocity and the pump torque that is computed from the initial pump velocity, initial volume conditions, and the homologous curves. This quantity must be nonzero if the relative pump motor torque table is entered.

W9(R) TF2 friction torque coefficient ($N{\bullet}m$, $lb_f{\bullet}ft$). This parameter multiplies the speed ratio (absolute pump speed/rated speed) to the second power. The friction torque factors are summed together.

W10(R) TF0, friction torque coefficient ($N{\bullet}m$, $lb_f{\bullet}ft$). This is constant frictional torque.

W11(R) TF1, friction torque coefficient ($N{\bullet}m$, $lb_f{\bullet}ft$). This multiplies the speed ratio to the first power.

W12(R) TF3, friction torque coefficient. ($N{\bullet}m$, $lb_f{\bullet}ft$). This multiplies the speed ratio to the third power.

A7.9.13 Card ccc0308, Pump Variable Inertia Card

Pump inertia is given by Word 6 of Card ccc0302 if this card is not entered. If this card is entered, pump inertia is computed from

$$I = I_3S^3 + I_2S^2 + I_1S^1 + I_0$$

where S is the relative pump speed defined as the absolute value of the pump rotational velocity divided by the rated rotational velocity.

W1(R) Relative speed at which to use the cubic expression for inertia. When the relative speed is less than this quantity, the inertia from Word 6 of Card ccc0302 is used.

W2-W5(R) I_3, I_2, I_1, I_o (kg/m^2, $lb{\bullet}ft^2$).

A7.9.14 Card ccc0309, Pump-Shaft Connection Card

If this card is entered, the pump is connected to a SHAFT component. The pump may still be driven by a pump motor that can be described in this component, by a turbine also connected to the SHAFT component, or from torque computed by the control system and applied to the SHAFT component. The pump speed table may not be entered if this card is entered.

W1(I) Control component number of the shaft component.

W2(I) Pump disconnect trip. If this quantity is omitted or zero, the pump is always connected to the SHAFT. If nonzero, the pump is connected to the shaft when the trip is false and disconnected when the trip is true.

A7.9.15 Card ccc0310, Pump Stop Data Card

If this card is omitted, the pump will not be stopped by the program.

W1(R) Elapsed problem time for pump stop (s).

W2(R) Maximum forward velocity for pump stop (rad/s, rev/min).

W3(R) Maximum reverse velocity for pump stop (rad/s, rev/min). Reverse velocity is a negative number.

A7.9.16 Cards cccxx00 through cccxx99, Single-Phase Homologous Curves

These cards are needed only if W1 of Card ccc0301 is zero. There are sixteen possible sets of homologous curve data to completely describe the single phase pump operation, that is, a curve for each head and torque for each of the eight possible curve types or regimes of operation. Entering all sixteen curves is not necessary, but an error will occur from an attempt to reference one that has not been entered.

Card numbering is ccc1100 through ccc1199 for the first curve, ccc1200 through ccc1299 for the second curve, through ccc2600 to ccc2699 for the sixteenth curve. Data for each individual curve are input on up to 99 cards, which need not be numbered consecutively.

W1(I) Curve type. Enter one for a head curve; enter two for a torque curve.

W2(I) Curve regime. See **Table 2.3-1** of this manual for definitions. The possible integer numbers and the corresponding homologous curve octants are: 1 (HAN or BAN), 2 (HVN or BVN), 3 (HAD or BAD), 4 (HVD or BVD), 5 (HAT or BAT), 6 (HVT or BVT), 7 (HAR or BAR), and 8 (HVR or BVR).

W3(R) Independent variable. Values for each curve range from -1.0 to 0.0 or from 0.0 to 1.0 inclusive. The variable is v/a for W2(I) = 1, 3, 5, or 7 and a/v for W2(I) = 2, 4, 6, or 8. If the tabular data does not span the entire range of the independent variable, end point values are used for data outside the table. This usually leads to incorrect pump performance data. Thus, entering data to cover the complete range is recommended.

W4(R) Dependent variable. The variable is h/a^2 or b/a^2 for W2(I) = 1, 3, 5, or 7 and h/v^2 or b/v^2 for W2(I) = 2, 4, 6, or 8.

Additional pairs as needed are entered on this or following cards, up to a limit of 100 pairs.

A7.9.17 Cards cccxx00 through cccxx99, Two-Phase Multiplier Tables

These cards are needed only if W2 of Card ccc0301 is zero; xx is 30 and 31 for the pump head multiplier table and the pump torque multiplier table, respectively.

W1(I) Extrapolation indicator. This is not used, enter zero.

W2(R) Void fraction.

W3(R) Head or torque difference multiplier depending on table type.

Additional pairs of data as needed are entered on this or additional cards as needed, up to a limit of 100 pairs. Void fractions must be in increasing order.

A7.9.18 Cards cccxx00 through cccxx99, Two-Phase Difference Tables

These cards are required only if W3 of Card ccc0301 is zero. The two-phase difference tables are homologous curves entered in a similar manner to the single phase homologous data. Card numbering is ccc4100 through ccc4199 for the first curve, ccc4200 through ccc4299 for the second curve, through ccc5600 to ccc5699 for the sixteenth curve. Data are the same as the data for the single phase data except that the dependent variable is the difference between single phase and fully degraded two-phase data.

A7.9.19 Cards ccc6001 through ccc6099, Relative Pump Motor Torque Data

These cards are required only if W4 of Card ccc0301 is zero. If the pump velocity table is not being used and these cards are present, the torque-inertia equation is used. When the electrical power is supplied to the pump motor (the pump trip is off), the net torque is computed from the rated pump motor torque times the relative pump motor torque from this table and the torque from the homologous data. If the electrical power is disconnected from the pump (the pump trip is on), the pump motor torque is zero.

W1(R) Pump velocity (rad/s, rev/min).

W2(R) Relative pump motor torque.

Additional pairs as needed are added on this or additional cards, up to a maximum of 100 pairs.

A7.9.20 Card ccc6100, Time-Dependent Pump Velocity Control Card

This card is required only if W5 of Card ccc0301 is zero. The velocity table, if present, has priority in setting the pump velocity over the pump trip, the pump motor torque data, and the torque-inertia equation.

W1(I) Trip number. If the trip number is zero, the pump velocity is always computed from this table using time as the search argument. If the trip number is nonzero, the trip determines which table is to be used. If the trip is off, the pump velocity is set from the trip, the pump motor torque data, and the torque-inertia equation. If the trip is on, the pump velocity is computed from this table. If Word 3 is missing, the search variable in the table is time and the search argument is time minus the trip time. If this word is used, it takes precedence over the trip number used in Word 6 of the ccc0301 card.

W2(A) Alphanumeric part of variable request code. This quantity is optional. If present, this word and the next are a variable request code that specifies the search argument for the table lookup and interpolation. TIME can be selected, but the trip time is not subtracted from the advancement time.

W3(I) Numeric part of variable request code. This is assumed to be zero if missing.

A7.9.21 Cards ccc6101 through ccc6199, Time-Dependent Pump Velocity

These cards are required only if W5 of Card ccc0301 is zero.

W1(R) Search variable. Units depend on the quantity selected for the search variable.

W2(R) Pump velocity (rad/s, rev/min).

Additional pairs as needed are added on this or additional cards, up to a maximum of 100 pairs. Time values must be in increasing order.

A7.10 Multiple Junction Component

A multiple junction component is indicated by MTPLJUN on Card ccc0000.

The one or more junctions specified by this component can connect volumes in the same manner as several single junction components except that all the volumes connected by the junctions in the component must be in the same hydrodynamic system. If this restriction is violated, corrective action is to merge the hydrodynamic systems. For major edits, minor edits, and plot variables, the junctions in the multiple junction component are numbered ccciinn00, where nn is the set number and ii is the junction number within the set. The quantity nn may be 01 through 99; ii is 01 for the first junction described in a set and incremented by one for each additional junction ($1 \leq ii \leq 99$).

A7.10.1 Card ccc0001, Multiple Junction Information Card

W1(I) Number of junctions, nj. This number must be >0 and <100.

W2(I) Initial condition control. This word is optional and, if missing, is assumed to be zero. If zero is entered, the initial conditions on Cards ccc1nnm are velocities; if one is entered, the initial conditions are mass flows.

A7.10.2 Cards ccc0nnm, Multiple Junction Geometry Card

Junctions are described by one or more sets of data, nn being the set number and m being the card number within a set. The junctions are numbered as ccciinn00, where ii is 01 for the first junction described in a set and increments by one for each additional junction. The quantity nn may be 01 through 99, and m may be 1 through 9. Cards are processed by increasing set number nn, and cards within a set by increasing m. Neither nn or m need be strictly consecutive.

W1(I) From connection code to a component. This refers to the component from which the junction coordinate direction originates. For connecting to a time dependent volume, the connection code is ccc000000, where ccc is the component number of the time dependent volume. An old or an expanded format can be used to connect all other volumes. In the old format, use ccc000000 if the connection is to the inlet side of the component and use ccc010000 if the connection is to the outlet side of the volume. In the expanded format, the connection code is cccvv000n, where ccc is the component number, vv is the volume number, and n indicates the face number. A nonzero n specifies the expanded format. The number n equal to 1 and 2 specifies the inlet and outlet faces respectively for the volume's coordinate direction (see Section 2.1). The number n equal to 3 through 6 specifies crossflow. The number n equal to 3 and 4 would specify inlet and outlet faces for the second coordinate direction; n equal to 5 and 6 would do the same for the third coordinate direction.

W2(I) To connection code to a component. This refers to the component at which the junction coordinate direction ends. See the description for W1 above.

W3(R) Junction area (m^2, ft^2). If zero, the area is set to the minimum volume area of the adjoining volumes. For abrupt area changes, the junction area must be equal to or smaller than the minimum of the adjoining volume areas. For smooth area changes, there are no restrictions.

W4(R) Forward flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is positive or zero. Note: a variable loss coefficient may be specified. See Section A7.10.5.

W5(R) Reverse flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is negative. Note: a variable loss coefficient may be specified. See Section A7.10.5.

W6(I) Junction control flags. This word has the packed format efvcahs. It is not necessary to input leading zeros.

The digit e specifies the modified PV term in the energy equations. e=0 means that the modified PV term will not be applied, and e=1 means that it will be applied.

The digit f specifies CCFL options. f=0 means that the CCFL model will not be applied, and f=1 means that the CCFL model will be applied.

The digit v is not used and should be input as zero (v=0). The horizontal stratification entrainment/pullthrough model is not used.

The digit c specifies choking options. c=0 means that the choking model will be applied, and c=1 means that the choking model will not be applied.

The digit a specifies area change options. a=0 means either a smooth area change or no area change, and a=1 means an abrupt area change.

The digit h specifies nonhomogeneous or homogeneous. h=0 specifies the nonhomogeneous (two-velocity momentum equations) option; h=2 specifies the homogeneous (single-velocity momentum equation) option. For the homogeneous option (h=2), the major edit printout will show h=1.

The digit s specifies momentum flux options. s=0 uses momentum flux in both the to and from volume. s=1 uses momentum flux in the from volume, but not in the to volume. s=2 uses momentum flux in the to volume, but not in the from volume. s=3 does not use momentum flux in either the to volume or the from volume.

W7(R) Subcooled discharge coefficient. This quantity is applied only to subcooled liquid choked flow calculations. The quantity must be >0.0 and ≤2.0.

W8(R) Two-phase discharge coefficient. This quantity is applied only to two-phase choked flow calculations. The quantity must be >0.0 and ≤2.0.

W9(R) Superheated discharge coefficient. This quantity is applied only to superheated vapor choked flow calculations. The geometry must be > 0.0 and ≤ 2.0.

W10(I) From volume increment. Words 1 and 2 contain the from and to connection codes respectively for the first junction defined by the set. If the set defines more than one junction, connection codes for the following junctions are given by the connection code of the previous junction plus the increments in Words 10 and 11. The increments may be positive, negative, or zero. Junctions are defined up to the limit in Word 13. Words 3 through 8 apply to all junctions defined by the set. If additional sets are entered, Words 1 and 2 apply to the next junction, and increments are applied as with the first set. Word 13 for the second and following sets must be greater than Word 13 of the preceding set, and Word 13 of the last set must equal nj. A new set is used whenever a new increment is needed, Words 3 through 9 need to be changed, or a change in junction numbering is desired.

W11(I) To volume increment. See description for Word 10.

W12(I) Enter zero. This is reserved for future capability.

W13(I) Junction limit. Described above.

A7.10.3 Cards ccc1nnm, Multiple Junction Initial Condition Cards

Initial velocities are entered using one or more sets of data. The processing of sets of data is identical to that described in Section A7.10.2 except that there need be no relationship in the division of junctions within sets between these cards (ccc1nnm) and the multiple junction geometry cards (ccc0nnm). Likewise, these cards do not affect the numbering of the junctions.

W1(R) Initial liquid velocity or mass flow. This quantity is either velocity (m/s, ft/s) or mass flow (kg/s, lb/s), depending on control Word 2 of Card CCC0001.

W2(R) Initial vapor velocity or mass flow. This quantity is either velocity (m/s, ft/s) or mass flow (kg/s, lb/s), depending on control Word 2 of Card CCC0001.

W3(I) Junction limit number.

A7.10.4 Cards ccc2nnm, Multiple Junction Diameter and CCFL Data Cards

These cards are optional. The defaults indicated for each word are used if the card is not entered. If the card is being used to specify only the junction hydraulic diameter for the interphase drag calculation (i.e., f=0 in Word 6 of Cards ccc0nnm), then the diameter should be entered in Word1 and any allowable values should be entered in Words 2 through 4 (will not be used). If this card is being used for the CCFL model (i.e., f=1 in Word 6 of Cards ccc0nnm), then enter all four words for the appropriate CCFL model if values different from the default values are desired. The processing of sets of data is identical to that described in Section A7.10.2 except that there need be no relationship in the division of junctions within sets between these cards (ccc1nnm) and the multiple junction geometry cards (ccc0nnm). Likewise, these cards do not affect the numbering of the junctions.

W1(R) Junction hydraulic diameter, D_j (m, ft). This is the junction hydraulic diameter used in the CCFL correlation equation and interphase drag and must be $\geq$0. This number should be computed from 4.0*(junction area)/(wetted perimeter). If a zero is entered or if the default is used, the junction diameter is computed from 2.0*(JUNCTION AREA/π)**0.5. See Word 3 of Card ccc0nnm for junction area.

W2(R) Flooding correlation form, β. If zero, the Wallis CCFL form is used. If one, the Kutateladze CCFL form is used. If between zero and one, Bankoff weighting between the Wallis and Kutateladze CCFL forms is used. This number must be $\geq$0 and $\leq$1. The default value is 0 (Wallis form).

W3(R) Gas intercept, c. This is the gas intercept used in the CCFL correlation (when $H_f^{1/2} = 0$) and must be >0. The default value f is 1.

W4(R) Slope, m. This is the slope used in the CCFL correlation and must be >0. The default value is 1.

W5(I) Junction limit number.

A7.10.5 Card ccc3nnm, Multiple Junction Form Loss Data Card

This card is optional. The user specified form loss is given in Words 4 and 5 of Card ccc0nnm if this card is not entered. If this card is entered, the form loss coefficient is calculated from

$$K_f = A_f + B_f Re^{-c_f}$$

$$K_r = A_r + B_r Re^{-c_r}$$

where K_f and K_r are the forward and reverse form loss coefficient. A_f and A_r are the Words 4 and 5 of Card ccc0nnm. Re is the Reynolds number based on mixture fluid properties. If this card is being used for the form loss calculation, then enter all five words for the appropriate expression.

W1(R) B_f ($\geq$0). This quantity must be greater than or equal to zero.

W2(R) c_f ($\geq$0). This quantity must be greater than or equal to zero.

W3(R) B_r ($\geq$0). This quantity must be greater than or equal to zero.

W4(R) c_r ($\geq$0). This quantity must be greater than or equal to zero.

W5(I) Junction limit number.

A7.11 Accumulator Component

An accumulator component is indicated by ACCUM on Card ccc0000. For major edits, minor edits, and plot variables, the volume in the accumulator component is numbered ccc010000, and the junction in the accumulator component is numbered ccc010000.

An accumulator is a lumped parameter component treated by special numerical techniques that model both the tank and surgeline until the accumulator is emptied of liquid. When the last of the liquid leaves the accumulator, the code automatically resets the accumulator to an equivalent single volume with an outlet junction and proceeds with calculations using the normal hydrodynamic solution algorithm.

In the following input requirements, it is assumed that the component is an accumulator in which liquid completely fills the surgeline but may or may not occupy the tank. It is further assumed that the accumulator is not initially in the injection mode. Hence, the initial pressure must be input lower than the injection point pressure, including elevation head effects; and junction initial conditions may not be input (i.e., initial hydrodynamic velocities are set to zero in the code). It is further assumed that the noncondensable gas in the accumulator is nitrogen and that the gas and liquid are initially in equilibrium. No other junctions (except the accumulator junction) should be connected to the accumulator volume. The geometry of the tank may be cylindrical or spherical. The standpipe/surgeline inlet refers to the end of the pipe inside the tank itself (see Section 2.3.13).

A7.11.1 Cards ccc0101 through ccc0109, Accumulator Volume Geometry Cards

W1(R) Volume flow area (m^2, ft^2). This is the flow area of a cylindrical tank, or the maximum flow area of a spherical tank. In the case of a spherical tank, the flow area and the tank radius are related by the formula $A = \pi R^2$.

W2(R) Length of volume (m, ft). This is the length of the tank above the standpipe/surgeline inlet, where this inlet refers to the end of the pipe inside the tank itself.

W3(R) Volume of volume (m^3, ft^3). This is the volume of the tank above the standpipe/surgeline inlet, where this inlet refers to the end of the pipe inside the tank itself. The code requires that the volume, volume flow area, and length are consistent. For a cylindrical tank, W3=W1*W2, and at least two of the three quantities, W1, W2 or W3, must be nonzero. If one of the quantities is zero, it will be computed from the other two. For a spherical tank, W1 and W2 must be nonzero. If W3 is zero, it will be computed from the other two. If none of the words are zero, they must satisfy the consistency condition within a relative error $\pm$ 0.000001.

W4(R) Azimuthal angle (degrees). The absolute value of this angle must be $\leq$360 degrees. This quantity is not used in the calculation but is specified for possible automated drawing of nodalization diagrams.

W5(R) Inclination angle (degrees). Only +90 or -90 degrees is allowed. The accumulator is assumed to be a vertical tank with the standpipe/surgeline inlet (where this inlet refers to the end of the pipe inside the tank itself) at the bottom. This angle is used in the interphase drag calculation.

W6(R) Elevation change (m, ft). This is the elevation change from the standpipe/surgeline inlet (where this inlet refers to the end of the pipe inside the tank itself) to the top of the tank. A positive value is an increase in elevation. The absolute value of this quantity must be nonzero, less than or equal to the volume length, and have the same sign as the angle for vertical orientation. As with other components, this Word 6 is compared to the volume length (Word 2) to decide if the horizontal or vertical flow regime map is used. This is not important for this component, since the correlations that depend on the flow regime map are not needed for this component. The volume conditions are determined from the accumulator's special model.

W7(R) Wall roughness (m, ft).

W8(R) Hydraulic diameter (m, ft). This should be computed from 4.0*(volume flow area)/(wetted perimeter). If zero, the hydraulic diameter of the tank is computed from 2.0*(volume flow area/π)**0.5. A check is made that the pipe roughness is less than half the hydraulic diameter of the tank. See Word 1 for the volume flow area.

W9(I) Volume control flags. This word has the packed format tlpvbfe. It is not necessary to input leading zeros. Volume flags consist of scaler oriented and coordinate direction oriented flags. Only one value for a scaler oriented flag is entered per volume but up to three coordinate oriented flags can be entered for a volume, one for each coordinate direction. At present, the f flag is the only coordinate direction oriented flag. This word enters the scaler oriented flags and the x coordinate flag. The accumulator component forces all volume flags except for the f digit, and y and z coordinate flags are not read. The effective format is 00110f0 where 0 and 1 indicate fields as set by the accumulator component. The user must enter 0 in the digits marked with 0 and may enter 0 or 1 in the digits marked with 1.

The t flag is not used and must be set to 0. The thermal stratification model is not used for an accumulator component.

The l flag is not used and must be set to 0. The level tracking model is not used for an accumulator component.

The flag p is not used and may be input as 0 or 1. The major edit will show p=1. The water packing scheme is not used.

The flag v is not used and may be input as 0 or 1. The major edit will show v=1. The vertical stratification model is not used.

The flag b is not used and must be input as zero. The rod bundle interphase friction model is not used.

The flag e must be specified zero, since only a nonequilibrium (unequal temperature) calculation is allowed.

W10(I) Geometry flag (optional). To specify a cylindrical tank, set the flag equal to 0 (default); to specify a spherical tank, set the flag equal to 1.

A7.11.2 Card ccc0131, Additional Laminar Wall Friction Card

This card is optional. If this card is not entered, the default values are 1.0 for the shape factor and 0.0 for the viscosity ratio exponent.

W1(R) Shape factor for x-coordinate.

W2(R) Viscosity ratio exponent for x-coordinate.

A7.11.3 Card ccc0200, Accumulator Tank Initial Thermodynamics Conditions

W1(R) Pressure (Pa, lb_f/in^2).

W2(R) Temperature (K, ^oF).

W3(R) Boron concentration. Parts of boron per parts of liquid water. This word is optional.

A7.11.4 Card ccc1101, Accumulator Junction Geometry Card

W1(I) To connection code to a component. The from connection is not entered, since it is always from the accumulator. The to connection code refers to the component from which the junction coordinate direction originates. For connecting to a time-dependent volume, the connection code is ccc000000, where ccc is the component number of the time-dependent volume. An old or an expanded format can be used to connect all other volumes. In the old format, use ccc000000 if the connection is to the inlet side of the component and use ccc010000 if the connection is to the outlet side of the volume. In the expanded format, the connection code is cccvv000n, where ccc is the component number, vv is the volume number, and n indicates the face number. A nonzero n specifies the expanded format. The number n equal to 1 and 2 specifies the inlet and outlet faces respectively for the volume's coordinate direction (see Section 2.1). The number n equal to 3 through 6 specifies crossflow. The number n equal to 3 and 4 would specify inlet and outlet faces for the second coordinate direction; n equal to 5 and 6 would do the same for the third coordinate direction.

W2(R) Junction area (m^2, ft). This is the average area of the surgeline and standpipe.

W3(R) Forward flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is positive or zero. Note: a variable loss coefficient may be specified. See Section A7.11.5.

W4(R) Reverse flow energy loss coefficient. This quantity will be used in each of the phasic momentum equations when the junction velocity of that phase is negative. Note: a variable loss coefficient may be specified. See Section A7.11.5.

W5(I) Junction control flags. This word has the packed format efvcahs. It is not necessary to input leading zeros.

The accumulator model automatically disables the following terms as long as liquid remains in the accumulator. However, when the accumulator empties of liquid, the model is automatically converted to an active normal volume. The following terms are then enabled and used as defined.

The digit e is not used and should be input as zero (e=0). The modified energy model is not used.

The digit f is not used and should be input as zero (f=0). The major edit output will show f=0. The CCFL model is not used.

The digit v is not used and should be input as zero (v=0). The horizontal stratification entrainment/pullthrough model is not used.

The digit c specifies choking options. c=0 means that the choking model will be applied, and c=1 means the choking model will not be applied.

The digit a specifies area change options. a=0 means either a smooth area change or no area change, and a=1 is not allowed for an accumulator.

The digit h specifies nonhomogeneous or homogeneous. h=0 specifies the nonhomogeneous (two-velocity momentum equations) option; h=2 specifies the homogeneous (single-velocity momentum equation) option. For the homogeneous option (h=2), the major edit will show h=1.

The digit s specifies momentum flux options. s=0 uses momentum flux in both the to volume and the from volume. s=1 uses momentum flux in the from volume, but not in the to volume. s=2 or 3 is not allowed for an accumulator.

A7.11.5 Card ccc1102, Accumulator Junction Form Loss Data Card

This card is optional. The user-specified form loss is given in Words 3 and 4 of Card ccc1101 if this card is not entered. If this card is entered, the form loss coefficient is calculated from

$$K_f = A_f + B_f Re^{-c_f}$$

$$K_r = A_r + B_r Re^{-c_r}$$

where K_f and K_r are the forward and reverse form loss coefficient. A_f and A_r are the Words 3 and 4 of Card ccc1101. Re is the Reynolds number based on mixture fluid properties. If this card is being used for the form loss calculation, then enter all four words for the appropriate expression.

W1(R) B_f ($\geq$0). This quantity must be greater than or equal to zero.

W2(R) c_f ($\geq$0). This quantity must be greater than or equal to zero.

W3(R) B_r ($\geq$0). This quantity must be greater than or equal to zero.

W4(R) c_r ($\geq$0). This quantity must be greater than or equal to zero.

A7.11.6 Card ccc2200, Accumulator Tank Initial Fill Conditions, Standpipe/Surgeline Length/Elevation, And Tank Wall Heat Transfer Terms

W1(R) Liquid volume in tank (m^3, ft^3). This is the volume of water contained in the tank above the standpipe/surgeline inlet (where this inlet refers to the end of the pipe inside the tank).

W2(R) Liquid level in tank (m, ft). This is the liquid level of water contained in the tank above the standpipe/surgeline inlet (where this inlet refers to the end of the pipe inside the tank) entrance. For a cylindrical tank, either W1 or W2 must be specified as nonzero. For a spherical tank, W2 must be specified as nonzero. If one of the words is zero, it is computed from the other two.

W3(R) Length of surgeline and standpipe (m, ft). If input as zero, then the surgeline and standpipe are not modeled.

W4(R) Elevation drop of surgeline and standpipe (m, ft). This is the elevation drop from the standpipe/surgeline inlet (where this inlet refers to the end of the pipe inside the tank) entrance to the injection point. A positive number denotes a decrease in elevation.

W5(R) Tank wall thickness (m, ft). This is not allowed to be zero.

W6(I) Heat transfer flag. If zero, heat transfer will be calculated. If one, no heat transfer will be calculated.

W7(R) Tank density (kg/m^3, lb/ft^3). If zero, the density will default to that for carbon steel.

W8(R) Tank volumetric heat capacity ($J/kg \bullet K$, $Btu/lb \bullet {}^oF$). If zero, the heat capacity will default to that for carbon steel.

W9(I) Trip number. If zero or if no number is input, then no trip test is performed. If nonzero then this must be a valid trip number, the operations performed are similar to those performed for a trip valve. If the trip is false, then the accumulator is isolated and no flow through the junction can occur. If the trip is true, then the accumulator is not isolated and flow through the junction will occur in the normal manner for an accumulator.

The volume flags entered in W8 through W11 use the packed format tlpvbfe. It is not necessary to input leading zeros. Volume flags consist of scaler oriented and coordinate direction oriented flags. Only one value for a scaler oriented flag is entered per volume but three coordinate oriented flags are entered for a volume, one for each coordinate direction. At present, the f flag is the only coordinate direction oriented flag. The scaler oriented and coordinate oriented flags are entered in separate words and not all the digits are used in each word. The specific format is listed for each word followed by the options selected by each digit.

The digit t specifies whether the thermal front tracking model is to be used; t=0 specifies that the front tracking model is not to be used for the volume, and t=1 specifies that the front tracking model is to be used for the volume.

The digit l specifies whether the mixture level tracking model is to be used; l=0 specifies that the level model not be used for the volume, and l=1 specifies that the level model be used for the volume.

are

A8 CARDS 1CCCGXNN, HEAT STRUCTURE INPUT

These cards are used in NEW and RESTART type problems and are required only if heat structures are described. The heat structure card numbers are divided into fields, where

ccc is a heat structure number. The heat structure numbers need not be consecutive. We suggest, but the system does not require, that if heat structures and hydrodynamic volumes are related, they be given the same number.

g is a geometry number. The combination cccg is a heat structure geometry combination referenced in the heat structure input data. The g digit is provided to differentiate between different types of heat structures (such as fuel pins and core barrel) that might be associated with the same hydrodynamic volume.

x is the card type.

nn is the card number within a card type.

A8.1 Card 1cccg000, General Heat Structure Data

This card is required for heat structures. Use eight words for new data input or one word for deleting a heat structure.

A8.1.1 General Heat Structure Data Card

W1(I) Number of axial heat structures with this geometry, nh. This number must be >0 and <100.

W2(I) Number of radial mesh points for this geometry, np. This number must be <100. Enter >1 if no reflood is specified, and >2 if reflood is specified.

W3(I) Geometry type. Enter 1 for rectangular, 2 for cylindrical, and 3 for spherical. Spherical geometry is not allowed if reflood is specified. Cylindrical geometry must be specified when the gap conductance model is used.

W4(I) Steady state initialization flag. Use zero if the desired initial condition temperatures are entered on input Cards 1cccg401-1cccg499; use one if the steady-state initial condition temperatures are to be calculated by the code. If option one is chosen, the user is still required to enter temperatures on cards 1cccg402-1cccg499. In this case, the temperatures are used as starting points for the steady-state solutions. The user should therefore enter temperatures either below or above the minimum film boiling point to assure the respective pre-DNB or post-DNB steady-state condition is calculated. This is because the boiling curve is multi-valued.

W5(R) Left boundary coordinate (m, ft).

Warning. The reflood model, activated by the next three words, is not operational in RELAP5/MOD3.2. Work to regain reflood capabililty is in progress.

W6(I) Reflood condition flag. This quantity is optional if no reflood calculation is to be performed. This quantity may be 0, 1, 2, or a trip number. If zero, no reflood calculation is to be performed. If nonzero, all the heat structures in this heat structure/geometry are assumed to form a two-dimensional representation of a fuel pin. The radial mesh is defined on Card 1cccg1nn. Each heat structure represents an axial level of the fuel pin, with the first heat structure being the bottom level. Each heat structure should be connected to a hydrodynamic volume representing the same axial section of the coolant channel. The length of the axial mesh in the fuel pin is given by the height of the connected hydrodynamic volume. If the heat structure is fuel pins or heat exchanger tubes, the length factor (Word 5 on Cards 1cccg501-1cccg509) is the product of the hydrodynamic volume length and the number of pins or tubes (see Section 3.2). The heat structures represent the temperatures at the midpoint of the axial mesh. Once the reflood calculation is initiated, additional mesh lines are introduced at each end of the fuel pin and between the heat structures. Once the reflood calculation is initiated, it remains activated, and the two-dimensional heat conduction calculation uses a minimum of 2*nh+1 axial mesh nodes. Additional mesh lines are introduced and later eliminated as needed to follow the quench front. If 1 is entered, the reflood calculation is initiated in this heat structure geometry when the average pressure in the connected hydrodynamic volumes is less than 1.2×10^6 Pa, and the average void fraction in the interconnected hydrodynamic volumes is greater than 0.9 (i.e., nearly empty). If 2 is entered, the reflood calculation is initiated in this heat structure geometry when the average pressure in the connected hydrodynamic volumes is less than 1.2×10^6 Pa and the average void fraction in the interconnected hydrodynamic volumes is greater than 0.1 (i.e., dryout begins). If a trip number is entered, the reflood calculation is initiated when the trip is set true. When using the expanded trip number format, 1 and 2 are possible trip numbers. A 1 or 2 entered in this word is not treated as a trip number.

W7(I) Boundary volume indicator. Enter zero or one to indicate that reflood heat transfer applies to the left or right boundary, respectively.

W8(I) Maximum number of axial intervals. Enter 2, 4, 8, 16, 32, 64, or 128 to indicate the maximum number of axial subdivisions a heat structure can have. Storage is allocated for the number indicated, even though a transient may not require that level of subdivision.

A8.1.2 Heat Structure Delete Card

This card is entered only for RESTART problems. If entered, all heat structures associated with the heat structure geometry number cccg are deleted.

W1(A) Enter DELETE.

A8.2 Card 1cccg001, Gap Conductance Model Initial Gap Pressure Data

This card is needed only if the gap conductance model is to be used. If the card is entered, Word 1 of Card 1cccg100 must be zero, Cards 1cccg011 through 1cccg099, and Cards 1cccg201 through 1cccg299 are required. Word 2 of Card 201mmm00 must be 3, and a table of the gas component name and mole fraction must be specified in the gap material data (Cards 201mmm01 through 201mmm49).

W1(R) Initial gap internal pressure (Pa, lb_f/in^2).

W2(I) Gap conductance reference volume. This word is required. The pressure of the gas in a fuel pin for the gap conductance model is given by P(t) = P(O)/T(O)*T(t), where P(t) is the pressure in the fuel pin and T(t) is the temperature in the reference volume. P(O) is Word 1 above, and T(O) is the initial value, if the volume is also being defined with these input data or the value from the restart block. The reference volume is usually the hydrodynamic volume (i.e., the nine-digit number cccnn0000) most closely associated with the nonfuel region in a fuel pin at the top of a stack of fuel pellets.

A8.3 Card 1cccg003, Metal-Water Reaction Control Card

Cccg is a heat structure geometry number. If this card is not present, no metal-water reaction will be calculated.

W1(R) Initial oxide thickness on cladding’s outer surface.

A8.4 Card 1cccg004, Fuel Cladding Deformation Model Control Card

Cccg is a heat structure geometry number. If this card is not present, no deformation calculations will be done. If this card is present, then Card 1cccg001 must also be present.

W1(I) Form loss factor flag. Enter 0 if no additional form loss factors are to be calculated after a rod ruptures. Enter 1 if additional form loss factors are to be calculated. Either a 0 or a 1 must be entered.

A8.5 Cards 1cccg011 through 1cccg099, Gap Deformation Data

These cards are required for the gap conductance model only. The card format is sequential format, five words per set, describing nh heat structures.

W1(R) Fuel surface roughness (m, ft). This number must be $\geq$0. An appropriate value is 10^{-6} m. A negative entry is reset to 10^{-6} m with no errors.

W2(R) Cladding surface roughness (m, ft). This number must be either positive or zero. An appropriate value is 2 x 10^{-6} m. A negative entry is reset to 2 x 10^{-6} m with no errors.

W3(R) Radial displacement due to fission gas-induced fuel swelling and densification (m, ft). This number must be $\geq$0. A negative entry is reset to zero. An appropriate value can be obtained from calculations using FRAPCON-2 or FRAP-T6.

W4(R) Radial displacement due to cladding creepdown (m, ft). The value is normally negative. A positive entry is reset to zero. An appropriate value can be obtained from calculations using FRAPCON-2 or FRAP-T6.

W5(I) Heat structure number.

A8.6 Card 1cccg100, Heat Structure Mesh Flags

This card is required for heat structure input.

W1(I) Mesh location flag. If zero, geometry data, including mesh interval data, composition data, and source distribution data, are entered with this heat structure input. If nonzero, that information is taken from the geometry data from the heat structure geometry (cccg) number in this word. If this word is nonzero, the remaining geometry information described in Section A8.6 through Section A8.10 is not entered.

W2(I) Mesh format flag. This word is needed only if Word 1 is zero, though no error occurs if it is present when Word 1 is nonzero. The mesh interval data are given as a sequence of pairs of numbers in one of two formats to be used in Cards 1cccg101 through 1cccg199. If this word is 1 (format 1 on Cards 1cccg101-1cccg199), the pairs of numbers contain the number of intervals in this region and the right boundary coordinate. For the first pair, the left coordinate of the region is the left boundary coordinate previously entered in Word 5 of Card 1cccg000; for succeeding pairs, the left coordinate is the right coordinate of the previous pair. If this word is 2 (format 2 on Cards 1cccg101-1cccg199), the format is a sequential expansion of mesh intervals; i.e., the distance in Word 1 on Cards 1cccg101 through 1cccg199 is used for each interval starting from the leftmost, as yet unspecified, interval to and including the interval number specified in Word 2.

A8.7 Cards 1cccg101 through 1cccg199, Heat Structure Mesh Interval Data (Radial)

These cards are required if Word 1 of Card 1cccg100 is zero. In Format 1, the sum of the numbers of intervals must be np-1. In Format 2, the sequential expansion must be for np-1 intervals. The card numbers need not be sequential.

A8.7.1 Format 1

W1(I) Number of intervals. Enter the number of intervals, not the interval number.

W2(R) Right coordinate (m, ft).

A8.7.2 Format 2

W1(R) Mesh interval (m, ft.)

W2(I) Interval number.

A8.8 Cards 1cccg201 through 1cccg299, Heat Structure Composition Data (Radial)

These cards are required if Word 1 of Card 1cccg100 is zero and must not be entered otherwise. The card format is two numbers per set in sequential expansion format for np-1 intervals. The card numbers need not be in sequential order.

W1(I) Composition number. The absolute value of this quantity is the composition number, and it must be identical to the subfield mmm used in Heat Structure Thermal Property Data, Section A10. The sign indicates whether the region over which this composition is applied is to be included or excluded from the volume averaged temperature computation. If positive, the region is included; if negative, the region is not included. The option to exclude regions from the volume averaged temperature integration is to limit the integration to fuel regions only for use in reactivity feedback calculations. Gap and cladding regions should not be included in this case. If the gap conductance model is used, only one interval can be used for the gap model.

W2(I) Interval number.

A8.9 Card 1cccg300, Fission Product Decay Heat Flag

This card sets the fission product decay heat flag. The code will then treat Card 1CCCG301 as a gamma attenuation coefficient card. This card is not needed if fission product decay heat is not used on this heat structure.

W1(A) DKHEAT.

A8.10 Cards 1cccg301 through 1cccg399, Heat Structure Source Distribution Data (Radial)

These cards are required if Word 1 of Card 1cccg100 is zero and must not be entered otherwise. The card format is two numbers per set in sequential expansion format for np-1 intervals. The card numbers need not be in sequential order. Radial power peaking factors are entered here.

W1(R) Source value. These are relative values only and can be scaled by any factor without changing the results. By entering different values for the various mesh intervals, a characteristic shape of a power curve can be described.

W2(I) Mesh interval number.

If Card 1cccg300 is entered, then Card 1cccg301 is treated as a gamma attenuation coefficient card.

W1(R) Gamma attenuation coefficient. These are values dependent on the heat structure material. A value of 50 is recommended for stainless steel.

W2(I) Mesh interval number.

A8.11 Card 1cccg400, Initial Temperature Flag

This card is optional; if missing, Word 1 is assumed to be zero.

W1(I) Initial temperature flag. If this word is zero or -1, initial temperatures are entered with the input data for this heat structure geometry. If greater than zero, initial temperatures for this heat structure geometry are taken from the heat structure geometry number in this word.

A8.12 Cards 1cccg401 through 1cccg499, Initial Temperature Data

These cards are required if Word 1 of Card 1cccg400 is zero or -1.

A8.12.1 Format 1 (Word 1 on Card 1cccg400 = 0)

If Word 1 is zero, one temperature distribution is entered; and the same distribution is applied to all of the nh heat structures. The card format is two numbers per set in sequential expansion format for np mesh points.

W1(R) Temperature (K, ^{o}F).

W2(I) Mesh point number.

A8.12.2 Format 2 (Word 1 on Card 1cccg400 = -1)

If Word 1 of Card 1cccg400 is -1, a separate temperature distribution must be entered for each of the nh heat structures. The distribution for the first heat structure is entered on Card 1cccg401, the distribution for the second heat structure is entered on Card 1cccg402, and the remaining distributions are entered on consecutive card numbers. Continuation cards can be used if the data do not fit on one card.

W1-WNP(R) Temperature (K, ^{o}F). Enter the np mesh point temperatures in order from left to right.

A8.13 Cards 1cccg501 through 1cccg599, Left Boundary Condition Cards

These cards are required. The boundary condition data for the heat structures with this geometry are entered in a slightly modified form of sequential expansion using six quantities per set for the number of heat structures with this geometry (nh sets). The modification deals with Words 1 and 2.

W1(I) Boundary volume number or general table. This word specifies the hydrodynamic volume number (of the form cccnn000f) or general table associated with the left surface of this heat structure. These are used to specify the sink temperature. If zero, no volume or general table is associated with the left surface of this heat structure, and a symmetry or insulated boundary condition is used (i.e., a zero temperature gradient at the boundary), or a temperature of zero is used for a surface temperature or a sink temperature in boundary conditions. A boundary volume number is entered as a positive number. If f is 0 or 4, the volume coordinate associated values such as average volume velocity are taken from the x coordinate; if f is 2 or 1, volume coordinate associated values are taken from the y or z axes, respectively. These numbers define the flow direction parallel with tube bundles. Any flow in other directions is vectorally added to give the cross flow mass flux. Specifying a volume coordinate not in use is an input error. A general table is entered as a negative number (-1 through -999).

W2(I) Increment. This word and Word 1 of this card are treated differently from the standard sequential expansion. Word 1 of the first set applies to the first heat structure of the heat structure geometry set. The increment (normally 10000) is added to Word 1, which results in the hydraulic cell number associated with heat structure 2; etc. The increment is applied up to the limit in Word 6 of a set. Word 1 of the next set applies to the next heat structure, and increments are applied as for the first set. The increment may be zero or nonzero, positive or negative. If Word 1 is zero, this word should be zero. Additional examples are shown in Section 4 of Volume V.

W3(I) Boundary condition type.

If 0, a symmetry or insulated boundary condition is used (i.e., a zero temperature gradient is used at the boundary). The boundary volume must be 0.

If 1 or 1nn, a convective boundary condition where the heat transfer coefficient obtained from Heat Transfer Package 1 is used. The sink temperature is the temperature of the boundary volume. Word 1 must specify a boundary volume with this boundary condition type. The boundary volume cannot be a time-dependent volume.

There are several numbers allowed for Word 3 to activate convective boundary conditions for nonstandard geometries. A 1, 100, or 101 give the default values. The default convection and boiling correlations were derived mainly based on data from internal vertical pipe flow. Other possible input values are shown in **Table A8.13-1**. When modelling a vertical bundle, the rod or tube pitch-to-diameter ratio should be input on the 901 card. This has the effect of increasing the convective part of heat transfer such that users can input the true hydraulic diameter and get reasonable predictions.

Table A8.13-1 Card 501 and 601 Word 3 convection boundary type.

Word 3	Geometry Type
1,100,101	Default
110	Vertical bundle without crossflow (set P/D on 801/901 card)
111	Vertical bundle with crossflow (set P/D on 801/901 card)
130	Flat plate above fluid
134	Horizontal bundle

If <u>1000</u>, the temperature of the boundary volume or the temperature from the general table (as specified in Word 1) is used as the left surface temperature. If Word 1 is zero, the surface temperature is set to zero.

If <u>1xxx</u>, the temperature in general Table xxx is used as the left surface temperature.

If <u>2xxx</u>, the heat flux from Table xxx is used as the left boundary condition.

If <u>3xxx</u>, a convective boundary condition is used where the heat transfer coefficient as a function of time is obtained from general Table xxx. The sink temperature is the temperature of the boundary volume or from the table specified in Word 1. If Word 1 is zero, the sink temperature is set to zero.

If 4xxx, a convective boundary condition is used where the heat transfer coefficient as a function of surface temperature is obtained from general Table xxx. The sink temperature is the temperature of the boundary volume or from the table specified in Word 1. If Word 1 is zero, the sink temperature is set to zero.

If reflood is specified, the left boundary condition type must be same for all nh heat structures and, similarly, for the right boundary condition type. The left and right boundary types need not be the same, but neither can be 1000 or 1xxx.

W4(I) Surface area code. If zero, Word 5 is the left surface area. If one, Word 5 is (a) the surface area in rectangular geometry, (b) the cylinder height or equivalent in cylindrical geometry, or (c) the fraction of a sphere (0.5 is a hemisphere) in spherical geometry.

W5(R) Surface area or factor. As indicated in Word 4, this word contains the surface area (m^2, ft^2) or a geometry dependent multiplier (m^2, ft^2) for rectangular; (m, ft) for cylindrical; or dimensionless for spherical geometries). If the symmetry boundary condition is specified (Word 3=0), this word must still be entered nonzero.

W6(I) Heat structure number.

A8.14 Cards 1cccg601 through 1cccg699, Right Boundary Condition Cards

These cards are required. These cards are the same as Cards 1cccg501 through 1cccg599, except for the right boundary. The left and right surface areas must be compatible with the geometry.

A8.15 Cards 1cccg701 through 1cccg799, Source Data Cards

These cards are required for heat structure data. The card format is sequential expansion format, five words per set, describing nh heat structures.

W1(I) Source type. If zero, no source is used. If a positive number is less than 1000, power from the general table with this number is used as the source. If 100000 through 199994, the number has the form 1zzzzt, and the source is taken from a reactor kinetics calculation. The field zzzz must be 0000 for point reactor kinetics and is the zone number for nodal reactor kinetics. The zone number specified must be in use in the nodal kinetics model. The field t=0 specifies total reactor power, t=1 specifies total decay power, t=2 specifies fission power, t=3 specifies fission product decay power, and t=4 specifies actinide decay power. If 10001 through 14095, the source is the control variable whose number is this quantity minus 10000.

W2(R) Internal source multiplier. Axial peaking factors may be entered here. These values are multiplied by the power in the general table number in Word 1 to obtain the total power generated in this heat structure. These factors are not relative factors.

W3(R) Direct moderator heating multiplier for left boundary volume (see Section 3.3).

W4(R) Direct moderator heating multiplier for right boundary volume (see Section 3.3).

W5(I) Heat structure number.

A8.16 Card 1cccg800, Additional Left Boundary Option

W1(I) If this card is not entered or if this word is zero, the nine word format is used on cards 1cccg801 through 1cccg899. If this word is one, the twelve word format is used on the cards.

A8.17 Cards 1cccg801 through 1cccg899, Additional Left Boundary Cards

These cards are required whenever the left boundary communicates energy with the left hand fluid volume. The cards are in sequential expansion format, nine words per set, describing nh heat structures. Sequential expansion would only be used where the critical heat flux value was not of importance, since the length to all heat structures in the expansion would be the same. Words 2-8 are used for the CHF correlation.

Nine-word format:

W1(R) Heat transfer hydraulic diameter (i.e., heated equivalent diameter) (m, ft). This is 4*(flow area)/(heated perimeter) and is recommended to be greater than or equal to the volume hydraulic diameter since (heated perimeter) $\leq$(wetted perimeter). It is possible to input this diameter to be less than the volume hydraulic diameter. If Word 1 equals 0.0, the volume hydraulic diameter is used.

W2(R) Heated length forward (m, ft). Distance is from the heated inlet to the center of this slab. This quantity will be used when the liquid volume velocity is positive or zero. This is used to get the hydraulic entrance length effect. This is used only for the CHF correlation. It must be >0. To ignore the length effect, put in a large number (i.e., $\geq$ 10.0).

W3(R) Heated length reverse (m, ft). Distance is from the heated outlet to the center of this slab. This quantity will be used when the liquid volume velocity is negative. This is used to get the hydraulic entrance length effect. This is used only for the CHF correlation. It must be >0. to ignore the length effect, put in a large number (i.e., $\geq$ 10.0).

W4(R) Grid spacer length forward (m, ft). Distance is from the center of this slab to the nearest grid or obstruction upstream. This quantity will be used when the liquid volume velocity is positive or zero. This is used to get the boundary layer disturbance and atomization effect of a grid spacer in rod bundles. This is used only for the CHF correlation. If the grid K loss (Word 6) is zero, Word 4 is not used.

W5(R) Grid spacer length reverse (m, ft). Distance is from the center of the slab to the nearest grid or obstruction downstream. This quantity will be used when the liquid volume velocity is negative. This is used to get the boundary layer disturbance and atomization affect of a grid space in rod bundles. This is used only for the CHF correlation. If the grid K loss (Word 7) is zero, Word 5 is not used.

W6(R) Grid loss coefficient forward. Used for forward flow in rod bundles. This quantity is used when the liquid volume velocity is positive or zero. This is used only for CHF calculation.

W7(R) Grid loss coefficient reverse. Used for reverse flow in rod bundles. This quantity is used when the liquid volume velocity is negative. This is used only for the CHF correlation.

W8(R) Local boiling factor. Enter 1.0 if there is no power source in the heat structure or if the local equilibrium quality is negative (i.e., liquid is subcooled and void is zero). This is the local heat flux/average heat flux from start of boiling. If the power profile is not flat, a steady state run may help determine this number. This number must be greater than 0.0.

W9(I) Heat structure number.

Twelve-word format (Word 1 = 1 on Card 1cccg800). The first eight words of this format is identical to the nine-word format.

W9(I) Natural circulation length (m, ft). This should be the height of a hydraulic natural convection cell. For a heated vertical plate, this is the total height of the plate. For inside a horizontal tube, this should be the inside tube diameter. For the outer surface of vertical or horizontal bundles, it is suggested to use the heated bundle height in the vertical direction. When using the nine word format, this quantity is set to Word 1, the heat transfer hydraulic diameter.

W10(R) Rod or tube pitch-to-diameter ratio. The default is 1.1. The maximum is 1.6. It is not used unless Word 3 on the 501 card is 110 or 111.

W11(R) Fouling factor. This factor is applied to the heat transfer correlations and may be used to represent fouling or to run sensitivity studies. This quantity must be a positive nonzero number. When using the nine-word format, this quantity is set to 1.0.

W12(I) Heat structure number.

A8.18 Card 1cccg900, Additional Right Boundary Option

This card is the same as Card 1cccg800 but applies to the right boundary.

A8.19 Cards 1cccg901 through 1cccg999, Additional Right Boundary Cards

These cards are the same as Cards 1cccg801 through 1cccg899 but applies to the right boundary.

A9 CARD 60000000, RADIATION MODEL CONTROL CARD

Any heat structure may radiate to any other heat structure or set of heat structures in a user-defined enclosure. An enclosure is a set of heat structures that communicate via thermal radiation. The calculation ignores fluid in the enclosure.

W1(I) Number of sets of radiation enclosures, NSET. This word must be less than 100 and greater than 0 for radiation to be on.

A9.1 Card 6ss00000, Radiation Set Card

SS is the set number. One of these cards must be input for each radiating set. The first word is required; the other three are optional.

W1(I) Number of radiating heat slabs, NRH. This word is the number of radiating heat slabs (surfaces) that participate in radiation heat transfer in set SS. The maximum is 99.

W2(R) Minimum temperature, TRMIN (K, ^{o}F). This word is the minimum temperature of all surfaces in a radiation enclosure below which radiation will no longer be calculated. The default value is 900 K.

W3(R) Minimum void fraction, VOIDMN. This word is the minimum void fraction below which radiation will no longer be calculated. The default value is 0.75. Each volume connected to any of the radiating surfaces in the set is checked and if any have a void fraction greater than Word 3, radiation stays on in the enclosure set.

W4(I) View factor set, REFSET. If input, this is the number of the set (SS) from which view factors are to be obtained. If no number is found here, the view factors must be input for this set.

A9.2 Cards 6ssnn001 through 6ssnn099, Radiation Heat Structure Data

For these cards, ss must take on every value from 1 to NSET (Word 1 in Card 60000000), and nn must take on every value from 1 to NRH (Word 1 on Card 6ss00000) for each ss. Data are entered for each conductor surface that participates in radiation heat transfer.

W1(I) Heat structure geometry level, JRH. This word is cccg0zz, where cccg is the heat structure geometry combination of NH, and zz is the axial level number participating in radiation.

W2(I) Surface flag, JLR. For this word, 0=left surface, and 1=right surface of nn.

W3(R) Emissivity of surface nn.

A9.3 Cards 6ssnn101 through 6ssnn199, Radiation View Factors

There are NRH•NRH values in each set. ss is the set number (from 1 to NSET). nn is the surface number (from 1 to NRH). For a given nn, the sum of the view factors must be 1.0, and the view factor times the surface area must equal the view factor times the area of the receiving surface.

W1(R) View factor, VFIJ. View factor from surface nn to surface W2(I).

W2(I) Radiation surface number to which nn radiates. Repeat the above two words until view factors to all NHR surfaces from all surfaces are entered. Sequential expansion is used.

A10 CARDS 201MMMNN, HEAT STRUCTURE THERMAL PROPERTY DATA

These cards are used in NEW or RESTART problems. These cards are required if Cards 1cccgtxnn, Heat Structure Input Cards, are entered. These data, if present, are processed and stored even if no Cards1 cccgxnn are entered.

The subfield mmm is the composition number, and the cards with this subfield describe the thermal properties of composition mmm. The composition numbers entered on Cards 1cccg201 through 1cccg299 correspond to this subfield. A set of Cards 201mmmnn must be entered for each composition number used, but mmm need not be consecutive. During RESTART, thermal property may be deleted, new compositions may be added, or data may be modified by entering new data for an existing composition.

A10.1 Card 201mmm00, Composition Type and Data Format

This card is required.

W1(A) Material type. Thermal properties for four materials are stored within the program: carbon steel (C-STEEL), stainless steel (S-STEEL), uranium dioxide (UO_2), and zirconium (ZR). These properties are selected by entering the name in parentheses for this word. If a user-supplied table or function is to be used, enter TBL/FCTN for this word. At present, the data are primarily to demonstrate capability. The user should check whether the data are satisfactory. The word DELETE may be entered in RESTART problems to delete a composition.

The next two words are required only if TBL/FCTN is entered for W1.

W2(I) Thermal conductivity format flag or gap mole fraction flag. Enter 1 if a table containing temperature and thermal conductivity is to be entered; enter 2 if functions are to be entered. Enter 3 if the gap conductance model is used, and thus a table containing gas component names and mole fractions is to be entered.

W3(I) Volumetric heat capacity flag. Enter 1 if a table containing temperature and volumetric heat capacity is to be entered; enter -1 if a table containing only volumetric heat capacities is to be entered and the temperature values are identical to the thermal conductivity table; enter 2 if functions are to be entered.

A10.2 Cards 201mmm01 through 201mmm49, Thermal Conductivity Data or Gap Mole Fraction Data

These cards are required if W1 of Card 201mmm00 contains TBL/FCTN. For a table, enter pairs of temperatures and thermal conductivities or pairs of gas component names and mole fractions according to the specification of W2 of Card 201mmm00. One to 7 pairs of gas names and their mole fractions can be entered. The gas component names that may be entered are helium, argon, krypton, xenon, nitrogen, hydrogen, and oxygen. No particular order of the pairs is required. Do not enter any gas component with a zero mole fraction. Normalization of the total mole fraction to one is performed if the sum of the mole fractions entered is not one. The table of gas composition data is applicable to any gap and is required if Card 1 cccg001 is present.

A10.2.1 Table Format

If only one word is entered, that word contains the thermal conductivity that is assumed constant. Otherwise, pairs of temperatures and thermal conductivities are entered. The number of pairs or single entries is limited to 100. The temperatures must be in increasing order. The end-point temperatures must bracket the expected temperatures during the transient. That is, if the temperature is outside the bracketed range, a failure will occur, and a diagnostic edit will be printed out.

W1(R) Temperature (K, ^{o}F) or gas name. If only volumetric heat capacities are being entered, this word is not entered.

W2(R) Thermal conductivity (W/m•K, Btu/s•ft•^{o}F) or mole fraction.

A10.2.2 Functional Format

In the functional format, sets of nine quantities are entered, each set containing one function and its range of application. The function is

k = A0 + A1*TX + A2*TX**2 + A3*TX**3 + A4*TX**4+ A5*TX**(-1)

where TX = T-C, T is the temperature argument, and C is a constant. Each function has a lower and upper limit of application. The first function entered must be for the lowest temperature range. The lower limit of each following function must equal the upper bound of the previous function.

W1(R) Lower limit temperature (K, ^{o}F).

W2(R) Upper limit temperature (K, ^{o}F).

W3(R) A0 (W/m•K, Btu/s•ft•^{o}F).

W4(R) A1 (W/m•K^2, Btu/s•ft•^{o}F^2).

W5(R) A2 (W/m•K^3, Btu/s•ft•^{o}F^3).

W6(R) A3 (W/m•K^4, Btu/s•ft•^{o}F^4).

W7(R) A4 (W/m•K^5, Btu/s•ft•^{o}F^5).

W8(R) A5 (W/m, Btu/s•ft).

W9(R) C (K, ^{o}F).

A10.3 Cards 201MMM51 through 201MMM99, Volumetric Heat Capacity Data

These cards are required if W1 of Card 201MMM00 contains TB/.FCTN.The card number need not be consecutive.

A10.3.1 Table Format

If only one word is entered, that word contains the volumetric heat capacity that is assumed constant. Pairs of temperature and volumetric heat capacity are entered if the temperatures are different than the thermal conductivity table or if functions are used for thermal conductivity. If the temperature values are identical, only the volumetric heat capacities need be entered. The number of pairs or single entries are limited to one hundred. The temperatures must be in increasing order. The end-point temperatures must bracket the expected temperatures during the transient. That is, if the temperature is outside the bracketed range, a failure will occur, and a diagnostic edit will be printed out.

W1(R) Temperature (K, ^oF). If only volumetric heat capacities are being entered, this word is not entered.

W2(R) Volumetric heat capacity (J/m^3K, $Btu/ft^3\ ^oF$). This is ρC_p, where ρ is density (kg/m^3, lb/ft^3) and C_p is specific heat capacity ($J/kg{\cdot}K$, $Btu/lb{\cdot}^oF$).

A10.3.2 Functional Format

In the functional format, sets of nine quantities are entered, each set containing one function and its range of application. The function is cρ = A0 + A1*TX + A2*TX**2 + A3*TX**3 + A4*TX**4 + A5*TX**(-1), where TX = T - C, and T is the temperature argument. Each function has a lower and upper limit of application. The first function entered must be for the lowest temperature range. The lower limit of each following function must equal the upper bound of the previous function.

W1(R) Lower limit temperature (K, ^oF).

W2(R) Upper limit temperature (K, ^oF).

W3(R) A0 ($J/m^3\ K$, $Btu/ft^3\ ^oF$).

W4(R) A1 ($J/m^3\ K^2$, $Btu/ft^3\ ^oF^2$).

W5(R) A2 ($J/m^3\ K^3$, $Btu/ft^3\ ^oF^3$).

W6(R) A3 ($J/m^3\ K^4$, $Btu/ft^3\ ^oF^4$).

W7(R) A4 ($J/m^3\ K^5$, $Btu/ft^3\ ^oF^5$).

W8(R) A5 ($J/m^{3\cdot}$, Btu/ft^3).

W9(R) C (K, ^{o}F).

A11 CARDS 202TTTNN, GENERAL TABLE DATA

These cards are used only in NEW or RESTART type problems and are required only if any input references general tables. ttt is the table number, and table references such as for power, heat transfer coefficients, and temperatures refer to this number. Data must be entered for each table that is referenced, but ttt need not be consecutive. Tables entered but not referenced are stored, and this is not considered an error. During RESTART, general tables may be added, existing tables may be deleted, or existing tables may be modified by entering new data.

A11.1 Card 202ttt00, Table Type and Multiplier Data

W1(A) Table type. Enter POWER for power versus time; enter HTRNRATE for heat flux versus time; enter HTC-T for heat transfer coefficient versus time; enter HTC-TEMP for heat transfer coefficient versus temperature; enter TEMP for temperature versus time; enter REAC-T for reactivity versus time; enter NORMAREA for normalized area versus normalized stem position. In RESTART problems, DELETE can be entered to delete general table ttt. When a general table is used to define a FUNCTION type control system variable, table type REAC-T can be used to prevent undesirable units conversion, since no British to SI units conversion is done for REAC-T entries.

The following two, three, or four words are optional and allow trips and factors or units changes to be applied to the table entries. If the factors are omitted, the data are used as entered. One multiplier is used for time, power, heat flux, heat transfer coefficient, normalized stem position, and normalized area; a multiplier and additive constant are used for temperature as T = M*TX + C, where M is the multiplier, C is the additive constant, and TX is the temperature entered. The first one or two factors apply to the argument variable, time or temperature; one factor is applied if the argument is time, and two factors are used if the argument is temperature. The remaining one or two factors are used for the function, two factors being used if temperature is the function.

W2(I) Table trip number. This number is optional unless factors are entered. If missing or zero, no trip is used, and the time argument in the following table is the time supplied to the table for interpolation. If nonzero, the number is the trip number, and the time argument in the following table is -1.0 if the trip is false and the time supplied to the table minus the trip time if the trip is true. This field may be omitted if no factors are entered. This number must be zero or blank for tables that are not a function of time.

W3-W5(R) Factors. As described above, enter factors such that when applied to the table values entered, the resultant values have the appropriate units. For the NORMAREA table, the resultant values for both the normalized length and area must be $\geq$0 and $\leq$1.0.

A11.2 Cards 202ttt01 through 202ttt99, General Table Data

The card numbers need not be consecutive. The units given are the units required after the factors on Card 202ttt00 have been applied. Pairs of numbers are entered; the limit on the number of pairs is 99.

W1(R) Argument value (s, if time; K, ^{o}F, if temperature; dimensionless, if normalized stem position).

W2(R) Function value (W, MW, if power; K, ^{o}F, if temperature; W/m^2, Btu/s•ft^2, if heat flux; W/m^2•K, Btu/s•ft^2•^{o}F, if heat transfer coefficient; dollars, if reactivity; dimensionless, if normalized area).

The tables use linear interpolation for segments between table search argument values. For search arguments beyond the range of entered data, the end-point values are used.

A12 CARDS 30000000 THROUGH 39999999, REACTOR KINETICS INPUT

These cards are required if a space-independent (point) reactor kinetics or a nodal reactor kinetics calculation is desired. These cards may be entered in a new problem or on a restart. If no reactor kinetics data are present in a restart problem, the data will be added; if reactor kinetics data are already present, the data are deleted and replaced by the new data. A complete set of reactor kinetics data must always be entered. Initial conditions are computed the same for new or restart problems; the initial conditions can be obtained from assuming infinite operating time at the input power or from an input power history.

A12.1 Card 30000000, Reactor Kinetics Type Card

This card is required.

W1(A) Kinetics type. Enter POINT or DELETE. Enter POINT for the point reactor kinetics option. Enter DELETE in a restart problem if reactor kinetics is to be deleted. No other data are needed if reactor kinetics is being deleted.

W2(A) Feedback type. Enter SEPARABL, TABLE3, TABLE4, TABLE3A, TABLE4A. If Word 2 is not entered, a default value is assumed. If the kinetics type is POINT, the default is SEPARABL. If SEPARABL is entered, reactor kinetics feedback due to moderator density, void fraction weighted moderator temperature, and fuel temperature is assumed to be separable, and feedback data are entered on Cards 30000501 through 30000899. If TABLE3, TABLE4, TABLE3A, or TABLE4A is entered, reactivity is obtained from a table defining reactivity as a function of three or four variables using Cards 30001001 through 30002999. If TABLE3 or TABLE4 are entered, the variables are moderator density, void fraction weighted moderator temperature, fuel temperature, and boron density. If TABLE3A or TABLE4A is entered, the variables are void fraction, liquid moderator temperature, volume average fuel temperature, and boron concentration. If TABLE3 or TABLE3A is entered, the first three of the variables in one of the sets defined above are used, and if TABLE4 or TABLE4A is entered, all four variables are used.

A12.2 Card 30000001, Reactor Kinetics Information Card

W1(A) Fission product decay type. Enter NO-GAMMA for no fission product decay calculations, GAMMA for standard fission product decay calculations, or GAMMA-AC for fission product decay plus actinide decay calculations.

W2(R) Total reactor power (W). This is the sum of fission power, fission product decay power, and actinide decay power. Watts are used for both SI and British units. This must be >0.0.

W3(R) Initial reactivity (dollars). This quantity must be less than or equal to 0.0.

W4(R) Delayed neutron fraction over prompt neutron generation time (s^{-1}).

W5(R) Fission product yield factor. This is usually 1.0 for best-estimate problems, and 1.2 has been used with ANS73 data for conservative mode problems. The factor 1.0 is assumed if this word is not entered.

W6(R) ^{239}U yield factor. This is the number of ^{239}U atoms produced per fission times any conservative factor desired. The factor 1.0 is assumed if this word is not entered.

W7(R) Fissions per initial fissile atom, ψ. Used in

factor $(G(t) = 1.0 + (3.24 \cdot 10^{-6} + 5.23 \cdot 10^{-10} t)\, T^{0.4} \psi)$

to account for neutron capture in fission products when using ANS79-1 or ANS79-3 option. Entering this quantity as a nonzero includes the G factor as part of the decay heat. The factor is not included if this quantity is not entered or is entered as zero. Entering this word as a positive quantity indicates that the equation is to be used for shutdown time up to 10^4 s, and the table is to be used from that time on. Entering this word as a negative number indicates that the table is to be used for all shutdown times. Note that there is a discontinuity in G(t) when switching between and equation and the table. The standard indicates that the table can be used for all shutdown times and that would result in a higher neutron absorption capture effect. The magnitude of this quantity if nonzero must be greater than or equal to 1.0 and less than or equal to 3.0.

W8(R) Reactor operating time T. This quantity is the T in the expression given in W7 above. The unit for this quantity is given in the next word. If not entered or entered as zero, this quantity defaults to 52 wk. This quantity is used only if the power history data in Section A12.7 are not entered. When the power history data are entered, the reactor operating time is obtained from that data. When the power history data are not entered, an infinite operating time is assumed in initializing the decay heat variables, and if the equation form of G(T) is being used, the quantity in this word is used with the shutdown period t set to zero to determine the G factor at the start of the simulation.The limit for this quantity is $1.2614 \cdot 10^8$ s.

W9(A) Units for W8 above. Must be sec, min, hr, day, wk.

A12.3 Card 30000002, Fission Product Decay Information

This card is optionally entered for POINT problems if W1 of Card 30000001 contains GAMMA or GAMMA-AC. If this card is not entered, the Proposed 1973 ANS Standard fission product data are used if default data are used.

W1(A) Fission product type. Enter ANS73, ANS79-1, or ANS79-3. If default fission product data are used, ANS73 specifies the Proposed 1973 ANS Standard data, ANS79-1 specifies the 1979 Standard data for ^{235}U, and ANS79-3 specifies the 1979 ANS Standard data for the three isotopes, ^{235}U, ^{238}U, and ^{239}Np. ANS79-3 also requires that power fractions for each isotope must be entered. If fission product data are entered, ANS73 and ANS79-1 specify only one isotope and ANS79-3 specifies three isotopes and also requires that the number of decay heat groups for each isotope be entered.

W2(R) Energy release per fission (MeV/fission). If not entered or zero, the default value of 200 MeV/fission is used.

W3-W5(R) If ANS79-3 is specified in W1, the fraction of power generated in ^{235}U, ^{238}U, and ^{239}Pu must be entered in these three words. The sum of the fractions must add to one.

W6-W8(I) Number of groups per isotope. If ANS79-3 is entered in W1 and default data are not being used, the number of decay groups for ^{235}U, ^{238}U, and ^{239}Pu must be entered in these words. The number of groups for each isotope must be less than or equal to 50.

A12.4 Cards 30000101 through 30000199, Delayed Neutron Constants

If these cards are missing, constants for the six generally accepted delayed neutron groups are supplied. Otherwise, two numbers for each delay group are entered, one or more pairs per card. Card numbers need not be consecutive. The number of pairs on these cards defines the number of delay groups. Up to 50 delay groups may be entered.

W1(R) Delayed neutron precursor yield ratio.

W2(R) Delayed neutron decay constant (s^{-1}).

A12.5 Cards 30000201 through 30000299, Fission Product Decay Constants

These cards are not needed if W1 of Card 30000001 is NO-GAMMA. If this word is GAMMA or GAMMA-AC, data from these cards or default data are used to define fission product decay. If the cards are missing, data as defined in W1 of Card 30000002 are supplied. Up to 50 fission product groups may be entered. Data are entered on cards similarly to Cards 30000101 through 30000199. The factor in W5 of Card 30000001 is applied to the yield fractions.

W1(R) Fission product yield fraction (MeV).

W2(R) Fission product decay constant (s^{-1}).

A12.6 Cards 30000301 through 30000399, Actinide Decay Constants

These cards are not needed unless W1 of Card 30000001 is GAMMA-AC. If GAMMA-AC is entered, data from these cards or default data are used to define actinide decay. If the cards are missing, default data are supplied.

W1(R) Energy yield from ^{239}U decay (Mev).

W2(R) Decay constant of ^{239}U (s^{-1}).

W3(R) Energy yield from ^{239}Np (Mev).

W4(R) Decay constant of ^{239}Np (s^{-1}).

A12.7 Cards 30000401 through 30000499, Power History Data

If these cards are not present, initial conditions for fission product and actinide groups are for steady-state operation at the power given in W2 of Card 30000001. This is equivalent to operation at that power for an infinite time. If these cards are present, the power history consisting of power and time duration is used to determine the fission product and actinide initial conditions. The power from gamma and actinide decay is assumed to be zero at the beginning of the first time duration. Data are entered in three- or six-word sets, one or more sets per card. Card numbers need not be consecutive.

W1(R) Reactor power (W). This quantity is the total reactor power, that is, the sum of fission power and decay power, and must be $\geq$0. If a decay power obtained from the power history exceeds this quantity, the fission power is assumed to be zero.

W2(R) Time duration. Units are as given in next word. This quantity must be greater than or equal to 0.

W3(A) Time duration units. Must be sec, min, hr, day, or wk.

W4-W6(R) Power fractions. If ANS79-3 is entered in W1 of Card 30000002, the power fractions for ^{235}U, ^{238}U, and ^{239}Pu must be entered in these words.

A12.8 Feedback Input

Feedback information for point kinetics information are entered on the following cards. For steady state computations in which constant power is desired, these cards can be omitted and the feedback reactivity will be zero.

A12.8.1 Cards 30000011 through 30000020, Reactivity Curve or Control Variable Numbers

Reactivity (or scram) curves from the general tables (Cards 202TTTNN) or control variables that contribute to reactivity feedback are specified on these cards. These cards are not used if there are no references to reactivity contributions from general tables or control variables. Tables and control variables referenced must be defined. No error is indicated if reactivity curves are defined but not referenced on this card, but memory space is wasted. Curve numbers, which are the TTT of the general table card number or control variable number code, are entered one or more per card. Card numbers need not be consecutive.

W1(I) Table or control variable number. Up to 20 numbers may be entered. Numbers from 1 through 999 indicate general table numbers. Numbers greater than 10000 indicate the control variable whose number is the entered number minus 10000.

A12.8.2 Cards 30000501 through 30000599, Density Reactivity Table

This table is required if the SEPARABL option is being used and if Cards 30000701 through 30000799 are entered. One or more pairs of numbers are entered to define reactivity as a function of moderator density. Data are entered one or more pairs per card, and card numbers need not be consecutive.

Up to 100 pairs may be entered. The table uses linear interpolation for segments between table search argument values. For search arguments beyond the range of entered data, the end-point values are used.

W1(R) Moderator density (kg/m^3, lb/ft^3).

W2(R) Reactivity (dollars).

A12.8.3 Cards 30000601 through 30000699, Doppler Reactivity Table

This table is required if the SEPARABL option is being used and if Cards 30000801 through 30000899 are entered. One or more pairs of numbers are entered to define Doppler reactivity as a function of volume-averaged fuel temperature. Heat structure composition data Cards 1cccg201-1cccg209 need to exclude the gap and the cladding for the volume-average fuel temperatures. Data are entered one or more pairs per card, and card numbers need not be consecutive. Up to 100 pairs may be entered. The table uses linear interpolation for segments between table search argument values. For search arguments beyond the range of entered data, the end-point values are used.

W1(R) Temperature (K, ^oF).

W2(R) Reactivity (dollars).

A12.8.4 Cards 30000701 through 30000799, Volume Weighting Factors

These cards are used only if the SEPARABL option is being used and are omitted if no reactor kinetics feedback from hydrodynamics is present. Each card contains the input for reactivity feedback due to conditions in one or more hydrodynamic volumes. Words 1 and 2 are a volume number and an increment (see Section A8.13). Words 3 and 4 are the reactivity data for the volume defined by Word1; Words 5 and 6 are the reactivity data for the volume defined by Word 1 plus Word 2; Words 7 and 8 contain data for the volume defined by Word 1 plus two times Word 2; etc. Each card must contain at least four words. Volumes must be defined by hydrodynamic component data cards, and any volume reactivity data must be defined only once on these cards. Card numbers need not be consecutive.

W1(I) Hydrodynamic volume number.

W2(I) Increment.

W3(R) Weighting factor for density feedback, W_{qi}. See Volume 1 of this manual for a discussion of the symbols.

W4(R) Water temperature coefficient, a_{Wi} (dollars/K, dollars/^oF). As defined in Volume 1, the weighting factor in Word 3 is not applied to this quantity.

A12.8.5 Cards 30000801 through 30000899, Heat Structure or SCDAP Component Weighting Factors

These cards are used only if the SEPARABL option is being used and are omitted if no reactor kinetics feedback from heat structures or SCDAP components are present. Each card contains the input for reactivity feedback due to conditions in one or more heat structures or SCDAP components representing fueled portions of the reactor. Data are entered in a manner similar to Cards 30000701 through 30000799.

For each heat structure specified on these cards, input on the heat structure data Cards 1CCCG2NN must define the fueled region as the region over which the volume-average temperature is computed.

Usually, either Word 3 or 4 is zero.

W1(I) Heat structure number, or SCDAP component IIJJ. II equals the axial node, and JJ equals the component number.

W2(I) Increment.

W3(R) Weighting factor for doppler feedback, W_{Fi}.

W4(R) Fuel temperature coefficient, a_{Fi} (dollars/K, dollars/^oF). As defined in Volume 1, the weighting factor in Word 3 is not applied to this quantity.

A12.8.6 Cards 30001701 through 30001799, Volume-Weighting Factors

These cards are used only if the TABLE3 or TABLE4 option is not being used. Each card contains the weighting factor for reactivity feedback due to moderator density (void fraction), void weighted moderator temperature (liquid moderator temperature), and boron density (boron concentration) in one or more hydrodynamic volumes. The quantities preceding the quantities within parentheses are used if TABLE3 or TABLE4 has been entered; the quantities within parentheses are used if TABLE3A or TABLE4A has been entered.The same factor is assumed to apply to all three effects, so only one factor is entered for each value. At least three quantities must be entered on each card. The use of the increment field is similar to that in Section A12.8.5.

W1(I) Hydrodynamic volume number.

W2(I) Increment.

W3(R) Weight factor.

A12.8.7 Cards 30001801 through 30001899, Heat Structure or SCDAP Component Weighting Factors

These cards are used only if the TABLE3 or TABLE4 option is not being used. Each card contains the weighting factor for reactivity feedback due to temperature in one or more heat structures or SCDAP components. At least three quantities must be entered on each card. The use of the increment field is similar to that in Section A12.8.5.

W1(I) Heat structure number or SCDAP component IIJJ. II is the axial node, and JJ is the component number.

W2(I) Increment.

W3(R) Weight factor.

A12.8.8 Cards 300019C1 through 300019C9, Feedback Table Coordinate Data

If the TABLE3 option is being used, the feedback table is a function of three variables: moderator density or void fraction (C=1), void weighted moderator temperature or liquid moderator temperature (C=2), and fuel temperature (C=3). If the TABLE4 option is being used, the feedback table is a function of four variables: the three above and boron density or boron concentration (C=4). Which variables are used depend on the feedback option used (see W2 in Section A12.1). These cards define the coordinates of the table, and table values are entered (on another card set) for each point defined by all combinations of the coordinate values. The table size is the product of the number of coordinate values entered for each variable. At least two coordinate points must be entered, and up to twenty points may be entered for each variable. Coordinate values are entered in increasing magnitude, one or more per card on one or more cards as desired. Card numbers need not be consecutive. The C in the parentheses above defines the C to be used in the card number.

W1(R) Coordinate value (kg/m^3, lb/ft^3 for moderator and boron densities; K, ^{o}F for moderator and heat structure temperatures; void fractions and boron concentrations are dimensionless).

A12.8.9 Cards 30002001 through 30002999, Feedback Table Data

Values defining the table are entered in pairs. The first is a coded number defining the position of the table entry. The second number is the table entry. One or more pairs may be entered on one or more cards as needed. Card numbers need not be consecutive. There is no required ordering for the coded number, but a coded number may be entered only once.

W1(I) Coded number. The coded number has the form ddmmffbb, where the letter pairs represent coordinate numbers of the independent variables of the table. The dd pair refers to moderator density, mm refers to moderator temperature, ff refers to heat structure temperature, and bb refers to boron density. The paired numbers range from 00 to one less than the number of coordinate values for that variable. The 00 pair refers to the first coordinate value. If boron dependence is not included, bb is always 00. All table values must be entered. (A future version may allow gaps that are filled in by interpolation.)

W2(R) Table value.

A13 CARDS 20300000 THROUGH 20499999, PLOT REQUEST INPUT DATA

The plotting capability is not currently active. Besides not being converted to machine-dependent form from the original CDC-7600 version, a proprietary plotting package was required. Most users use the strip option to write an ASCII coded file containing data to be plotted and interface this file to plotting routines available within their organizations.

A14 CARDS 205CCCNN OR 205CCCCN, CONTROL SYSTEM INPUT DATA

These cards are used in NEW and RESTART problems if a control system is desired. They are also used to define the generic control components employed with the self-initialization option. Input can also be used to compute additional quantities from the normally computed quantities. These additional quantities can then be output in major and minor edits and plots.

Two different card types are available for entering control system data, but only one type can be used in a problem. The digits ccc or cccc form the control variable number (i.e., control component number). The card format 205cccnn allows 999 control variables, where ccc ranges from 001 through 999. The card format 205ccccn allows 9999 control variables, where cccc ranges from 1 through 9999.

If the self-initialization option is selected, the data cards described in Section A14.2, Section A14.3.20, and Section A14.3.21 must be included. If loop flow control is to be included, the data cards described in Section A14.3.19 must also be included.

A14.1 Card 20500000, Control Variable Card Type

If this card is omitted, card type 205cccnn is used. If this card is entered, either card format can be selected. This card cannot be entered on RESTART problems if control components exist from the restart problem, in which case the card format from the restart problem must be used.

W1(I) Enter 999 to select the 205cccnn format or 9999 (4095 also allowed) to select the 205ccccn format.

A14.2 Card 205ccc00 or 205cccc0, Control Component Type Card

One card must be entered for each of the generic control components when using the self-initialization option.

W1(A) Alphanumeric name. Enter a name descriptive of the component. This name will appear in the printed output along with the component number. A limit of 10 characters is allowed for CDC 7600 computers, and a limit of 8 characters is allowed for most other computers.

W2(A) Control component type. Enter one of the component names, SUM, MULT, DIV, DIFFRENI, DIFFREND, INTEGRAL, FUNCTION, STDFNCTN, DELAY, TRIPUNIT, TRIPDLAY, POWERI, POWERR, POWERX, PROP-INT, LAG, LEAD-LAG, CONSTANT, SHAFT, PUMPCTL, STEAMCTL, or FEEDCTL, or the command, DELETE. If DELETE is entered, enter any alphanumeric word in Word 1 and zeros in the remaining words. No other cards are needed when deleting a component.

W3(R) Scaling factor. For a CONSTANT component, this quantity is the constant value. No additional words are entered on this card, and Cards 205ccc01 through 205ccc09 or 205cccc1 through 205cccc9 are not entered. For the PUMPCTL, STEAMCTL, or FEEDCTL components, this is the gain multiplier (G) for the output signal.

W4(R) Initial value.

W5(I) Initial value flag. Zero means no initial condition calculation and W4 is used as the initial condition; one means compute initial condition.

W6(I) Limiter control. Enter zero, or omit this and the following words if no limits on the control variable are to be imposed. Enter 1 if only a minimum limit is to be imposed, 2 if only a maximum limit is to be imposed, and enter 3 if both minimum and maximum limits are to be imposed.

W7(R) Minimum or maximum value. This word is the minimum or maximum value if only one limit is to be imposed or is the minimum value if both limits are to be imposed.

W8(R) Maximum value. This word is used if both limits are to be imposed.

A14.3 Cards 205ccc01 through 205ccc98 or 205cccc1 through 205cccc8, Control Component Data Cards

The format of these cards depends on the control component type. An equation is used to describe the processing by each component. The symbol Y represents the control variable defined by the component. The symbols A_j, j=1,2,...J, represent constants defined by the control component input data. The variables V_j, j=1,2,...J, represent any of the variables listed in the minor edit input description. Besides hydrodynamic component data, heat structure data, reactor kinetic data, etc., any of the control variables including the variable being defined may be specified. The symbol S is the scale factor (or G, the gain multiplier, for self-initialization control components) on Card 205ccc00 or 205cccc0. The variables V_j use the code's internal units (SI). To use British units, the user must convert from SI to British using the scale factor S (or the gain multiplier G) and the constants A_j.

See Section 8 of volume I for a detailed description of these models.

A14.3.1 Sum-Difference Component

This component is indicated by SUM in Word 2 of Card 205ccc00 or 205cccc0. The sum-difference component is defined by

$$Y = S(A_0 + A_1V_1 + A_2V_2 + ... + A_jV_j)$$

W1(R) Constant A_0.

W2(R) Constant A_1.

W3(A) Alphanumeric name of variable request code for V_1.

W4(I) Integer name of the variable request code for V_1. At least four words that define a constant and one product term must be entered. Additional sets of three words corresponding to Words 2 through 4 can be entered for additional product terms up to twenty product terms. One or more cards may be used as desired. Card numbers need not be strictly consecutive. The sign of A_j determines addition or subtraction of the product terms.

A14.3.2 Multiplier Component

This component is indicated by MULT in Word 2 of Card 205ccc00 or 205cccc0. The multiplier component is defined by

$$Y = SV_1V_2...V_j \ .$$

W1(A) Alphanumeric name of the variable request code for V_1.

W2(I) Integer name of the variable request code for V_1. At least two words must be entered. Additional pairs of words can be entered on this or additional cards to define additional factors. Card numbers need not be strictly consecutive.

A14.3.3 Divide Component

This component is indicated by DIV in Word 2 of Card 205ccc00 or 205cccc0. The divide component is defined by

$$Y = \frac{S}{V_1} \quad \text{or} \quad Y = \frac{V_2}{V_1} \ .$$

Specifying two words on the card indicates the first form, and specifying four words on the card indicates the second form. Execution will terminate if a divide by zero is attempted.

W1(A) Alphanumeric name of the variable request code for V_1.

W2(I) Integer name of the variable request code for V_1.

W3(A) Alphanumeric name of the variable request code for V_2.

W4(I) Integer name of the variable request code for V_2.

A14.3.4 Differentiating Components

These components are indicated by DIFFRENI or DIFFREND in Word 2 of Card 205ccc00 or 205cccc0. The differentiating component is defined by

$$Y = S\frac{dV_1}{dt} \ .$$

This is evaluated by

$$Y = S*[2(V_1 - V_{10})/\Delta t] - Y_o \qquad \text{(DIFFERENI)}$$

$$Y = S*(V_1 - V_{10})/\Delta t \qquad \text{(DIFFREND)}$$

where Δt is the time step, and V_{10} and Y_0 are values at the beginning of the time step. The numerical approximations for the DIFFRENI and INTEGRAL components are exact inverses of each other. However, an exact initial value is required to use the DIFFRENI component, and erroneous results are obtained if an exact initial value is not furnished. The DIFFREND component uses a simple difference approximation that is less accurate and is not consistent with the integration approximation, but does not require an initial value. For these reasons, use of DIFFRENI is not recommended.

Since differentiation, especially numerical differentiation, can introduce noise into the calculation, it should be avoided if possible. When using control components to solve differential equations, the equations can be arranged such that INTEGRAL components can handle all indicated derivatives except possibly those involving noncontrol variables.

W1(A) Alphanumeric name of variable request code for V_1.

W2(I) Integer name of variable request code for V_1.

A14.3.5 Integrating Component

This component is indicated by INTEGRAL in Word 2 of Card 205ccc00 or 205cccc0. The integrating component is defined by

$$Y = S\int_0^t V_1 dt$$

or, in Laplace notation,

$$y(s) = \frac{SV_1(s)}{s} \quad .$$

This is evaluated by

$$Y = Y_o + S*(V_1 + V_{10})*\Delta t/2$$

where Δ is the time step and Y_o and V_{10} are values at the beginning of the time step.

W1(A) Alphanumeric name of the variable request code for V_1.

W2(I) Integer name of the variable request code for V_1.

A14.3.6 Functional Component

This component is indicated by FUNCTION in Word 2 of Card 205ccc00 or 205cccc0. The component is defined by

$$Y = S[FUNCTION\ (V_1)]$$

where FUNCTION is defined by a general table. This allows the use of any function that is conveniently defined by a table lookup and linear interpolation procedure. The function component can also be used to set limiting values.

W1(A) Alphanumeric name of the variable request code for V_1.

W2(I) Integer name of the variable request code for V_1.

W3(I) General table number of the function.

A14.3.7 Standard Function Component

This component is indicated by STDFNCTN in Word 2 of Card 205ccc00 or 205cccc0. The component is defined by

$$Y = S[FNCTN (V_1, V_2, ...)]$$

where FNCTN is ABS (absolute value), SQRT (square root), EXP (e raised to power), LOG (natural logarithm), SIN (sine), COS (cosine), TAN (tangent), ATAN (arc tangent), MIN (minimum value), or MAX (maximum value). All function types except MIN and MAX must have only one argument; MIN and MAX function types must have at least two arguments and may have up to twenty arguments. If the control variable being defined also appears in the argument list of MIN or MAX, the old time value is used in the comparison.

W1(A) FNCTN.

W2(A) Alphanumeric name of the variable request code for V_1.

W3(I) Integer name of the variable request code for V_1.

A14.3.8 Delay Component

This component is indicated by DELAY in Word 2 of Card 205ccc00 or 205cccc0. The component is defined by

$$Y = SV_1 (t - t_d)$$

where t is time and t_d is the delay time.

W1(A) Alphanumeric name of the variable request code for V_1.

W2(I) Integer name of the variable request code for V_1.

W3(R) Delay time, t_d (s).

W4(I) Number of hold positions. This quantity, h, must be > 0 and $\leq$ 100. This quantity determines the length of the table used to store past values of the quantity V_1. The maximum number of time-function pairs that can be stored is h+2. The delay table time increment, d_{TM}, is $d_{TM} = t_d/h$. The delayed function is obtained by linear interpolation for $V_1(t - t_d)$ using the stored past history. As the problem is advanced in time, new time values are added to the table. Once the table is filled, new values replace values that are older than the delay time. There are no restrictions on t_dT or d_{TM} relative to the time steps on Cards 2nn. When a change in advancement time is made at a restart, the time values in this table are changed to have time values as if the problem in the restart had run to the new advancement time.

A14.3.9 Unit Trip Component

This component is indicated by TRIPUNIT in Word 2 of Card 205ccc00 or 205cccc0. The component is defined by

$Y = S*U(\pm T_1)$

where U is 0.0 if the trip, T_1, is false and is 1.0 if the trip is true. If the complement of T_1 is specified, U is 1.0 if the trip is false and 0.0 if the trip is true.

W1(I) Trip number. A minus sign may prefix the trip number to indicate that the complement of the trip is to be used.

A14.3.10 Trip Delay Component

This component is indicated by TRIPDLAY in Word 2 of Card 205ccc00 or 205cccc0. The component is defined by

$Y = ST_{rptim} (T_1)$

where T_{rptim} is the time the trip last turned true. If the trip is false, the value is -1.0; if the trip is true, the value is zero or a positive number.

W1(I) Trip number, T_1.

A14.3.11 Integer Power Component

This component is indicated by POWERI in Word2 of Card 205ccc00 or 205cccc0. The component is defined by

$Y = SV_1^I$.

W1(A) Alphanumeric name of the variable request code for V_1.

W2(I) Integer name of the variable request code for V_1.

W3(I) I.

A14.3.12 Real Power Component

This component is indicated by POWERR in Word 2 of Card 205ccc00 or 205cccc0. The component is defined by

$$Y = SV_1^R.$$

W1(A) Alphanumeric name of the variable request code for V_1.

W2(I) Integer name of the variable request code for V_1.

W3(R) R.

A14.3.13 Variable Power Component

This component is indicated by POWERX in Word 2 of Card 205ccc00 or 205cccc0. The component is defined by

$$Y = SV_1^{V_2} .$$

W1(A) Alphanumeric name of the variable request code for V_1.

W2(I) Integer name of the variable request code for V_1.

W3(A) Alphanumeric name of the variable request code for V_2.

W4(I) Integer name of the variable request code for V_2.

A14.3.14 Proportional-Integral Component

This component is indicated by PROP-INT in Word 2 of Card 205ccc00 or 205cccc0. The component is defined by

$$Y = S\left[A_1 V_1 + A_2 \int_0^t V_1 dt\right]$$

or in Laplace transform notation,

$$Y(s) = S\left[A_1 + \frac{A_2}{s}\right]V_1(s) .$$

If the control variable is initialized,

$$Y(t_o) = SA_1V_1(t_o) .$$

If it is desired that the output quantity Y remain constant as long as the input quantity remains constant, V_1 must initially be zero regardless of the initialization flag.

W1(R) A_1.

W2(R) A_2.

W3(A) Alphanumeric name of the variable request code for V_1.

W4(I) Integer name of the variable request code for V_1.

A14.3.15 Lag Component

This component is indicated by LAG in Word 2 of Card 205ccc00 or 205cccc0. This component is defined by

$$Y = \int_0^t \left(\frac{SV_1 - Y}{A_1} \right) dt$$

or, in Laplace transform notation,

$$Y(s) = \frac{S}{1 + A_1 s} V_1(s) .$$

If the control variable is initialized,

$$Y(T_0) = SV_1(t_0).$$

If the initialization flag is set on and if the initial values of Y and V_1 satisfy a specified relationship, Y remains constant as long as V_1 retains its initial value.

W1(R) Lag time, A_1 (s).

W2(A) Alphanumeric name of the variable request code for V_1.

W3(I) Integer name of the variable request code for V_1.

A14.3.16 Lead-Lag Component

This component is indicated by LEAD-LAG in Word 2 of Card 205ccc00 or 205cccc0. The component is defined by

$$Y = \frac{A_1 SV_1}{A_2} + \int_0^t \left(\frac{SV_1 - Y}{A_2} \right) dt$$

or, in Laplace transform notation,

$$Y(s) = S\frac{1 + A_1 s}{1 + A_2 s} V_1(s) .$$

If the control variable is initialized,

$Y(t_0) = SV_1(t_0)$.

If the initialization flag is set on and if the initial values of Y and V_1 satisfy a specified relationship, Y remains constant as long as V_1 retains its initial value.

W1(R) Lead time, A_1 (s).

W2(R) Lag time, A_1 (s).

W3(A) Alphanumeric name of the variable request code for V_1.

W4(I) Integer name of the variable request code for V_1.

A14.3.17 Constant Component

Cards 205ccc01 through 205ccc09 or 205cccc1 through 205cccc9 are not entered. The quantity in Word 3 of Card 205ccc00 or 205cccc0 is the constant value used for this component.

A14.3.18 Shaft Component

This component is indicated by SHAFT in Word 2 of Card 205ccc00 or 205cccc0. A GENERATR component may optionally be associated with a SHAFT component. The SHAFT component advances the rotational velocity equation

$$\sum_i I_i \frac{d\omega}{dt} = \sum_i \tau_i - \sum_i f_i \omega + \tau_c$$

where I_i is the moment of inertia of component i, ω is rotational velocity, τ_i is torque of component i, f_i is the friction factor of component i, and τ_c is an optional torque from a control component. The summations include the shaft as well as the pump, turbine, and generator components that are connected to the shaft.

The SHAFT control component differs somewhat from other control components. The scale factor on Card 205ccc00 or 205cccc0 must be 1.0. The initial value and optional minimum and maximum values have units (rad/s, rev/min), and British-SI units conversion are applied to these quantities. The output of the SHAFT in minor and major edits is in the requested units. Card number ranges are restricted so that both data to complete the SHAFT component description and optional data to describe a generator can be entered. Units conversion is applied to the following cards.

A14.3.18.1 Card 205ccc01 through 205ccc05 or 205cccc1 through 205cccc5, Shaft Description Card.

W1(I) Torque control variable number. If zero, there is no contribution to torque from the control system. If nonzero, the control variable with this number is assumed to be a torque and is added to the torques from the other components attached to the shaft. The torque must be in SI units.

W2(R) Shaft moment of inertia, I_i (kg•m^2, lb•ft^2).

W3(R) Friction factor for the shaft, f_i (N•m•s, lb_f•ft•s).

W4(A) Type of attached component. Enter either TURBINE, PUMP, or GENERATR.

W5(I) Component number. This is the hydrodynamic component number for a TURBINE or PUMP, or the control variable number for this SHAFT component if GENERATR.

Additional two-word pairs may be entered to attach additional components to the shaft, up to a total of ten components. Only one generator, the one which is defined as part of this SHAFT component, may be attached.

A14.3.18.2 Card 205ccc06 or 205cccc6, Generator Description Card. Each SHAFT component may optionally define an associated GENERATR component.

W1(R) Initial rotational velocity (rad/s, rev/min).

W2(R) Synchronous rotational velocity (rad/s, rev/min).

W3(R) Moment of inertia, I_i (kg•m^2, lb•ft^2).

W4(R) Friction factor, f_i (N•m•s, lb_f•ft•s).

W5(I) Generator trip number. When the trip is false, the generator is connected to an electrical distribution system and rotational velocity is forced to the synchronous speed. When the trip is true, the generator is not connected to an electrical system and the generator and shaft rotational velocity is computed from the rotational velocity equation.

W6(I) Generator disconnect trip number. If zero, the generator is always connected to the shaft. If nonzero, the generator is connected to the shaft when the trip is false and disconnected when the trip is true.

A14.3.19 PUMPCTL Component

This component is specified when using the self-initialization option and loop flow control is desired, but it is not limited to that use. For each PUMPCTL component enter:

W1(A) Alphanumeric name of setpoint variable.

W2(I) Parameter part of setpoint variable.

W3(A) Alphanumeric name of sensed variable.

W4(I) Parameter part of sensed variable.

W5(R) Scale factor(s) applied to sensed and setpoint values, S_i. Must be nonzero.

W6(R) Integral name time constant, T_2 (s).

W7(R) Proportional part time constant, T_1 (s).

Standard use of PUMPCTL controller require the following interpretation of the input data. W1 and W2 contain CNTRLVAR and ccc (or cccc), respectively, where ccc (or cccc) is a CONSTANT type control element containing the desired (setpoint) flow rate. W3 is MFLOWJ, and W4 is the junction number at which the flow is to be sensed and compared to the setpoint. W5 is the S_i value used to divide the difference between the desired (setpoint) and sensed flow rate to produce the error signal E_1. E_1 must be initially zero if it is intended to have the controller output remain constant as long as the input quantities remain constant. W6 and W7 are the T_2 and T_1 values, respectively. All variables having units must be in SI units.

A14.3.20 STEAMCTL Component

This component is specified when using the self-initialization option to control steam flow from one or more steam generators, but it is not limited to that use. For each STEAMCTL component enter:

W1(A) Alphanumeric name of setpoint variable.

W2(I) Parameter part of setpoint variable.

W3(A) Alphanumeric name of sensed variable.

W4(I) Parameter part of sensed variable.

W5(R) Scale factor(s) applied to sensed and setpoint values, S_j. Must be nonzero.

W6(R) Integral name time constant, T_4 (s).

W7(R) Proportional part time constant, T_4 (s).

Standard use of the STEAMCTL controller requires the following interpretation of the input data. W1 and W2 would contain CNTRLVAR and ccc (or cccc), respectively, where ccc (or cccc) is a CONSTANT type control element. This constant would be the desired (setpoint) cold leg temperature (for suboptions A and B) or secondary pressure (suboptions C and D). W3 would be TEMPF (for suboptions A and B) or P (for suboptions C and D), and W4 would be the volume number where the temperature (suboptions A and B) or pressure (suboptions C and D) is sensed. W5 is the S_j value used to divide the difference between the desired (setpoint) and sensed temperature (suboptions A and B) or pressure (suboptions C and D) to produce the error signal E_2. E_2 must be initially zero if it is intended to have the controller output remain constant as long as the input quantities remain constant. W6 and W7 are the T_4 and T_3 values respectively. All variables having units must be in SI units.

A14.3.21 FEEDCTL Component

This component is specified when using the self-initialization option to control feedwater flow to a steam generator, but it is not limited to that use. For each FEEDCTL component enter:

W1(A) Alphanumeric name of first setpoint variable.

W2(I) Parameter part of first setpoint variable.

W3(A) Alphanumeric name of sensed variable to be compared with first setpoint.

W4(I) Parameter part of sensed variable to be compared with first setpoint.

W5(R) Scale factor applied to sensed and setpoint values (first setpoint), S_k. Must be nonzero.

W6(A) Alphanumeric name of second setpoint variable.

W7(I) Parameter part of second setpoint variable.

W8(A) Alphanumeric name of sensed variable to be compared with second setpoint.

W9(I) Parameter part of sensed variable to be compared with second setpoint.

W10(R) Scale factor applied to sensed and setpoint values (second setpoint), S_m. Must be nonzero.

W11(R) Integral name time constant, T_6 (s).

W12(R) Proportional part time constant, T_5 (s).

Standard use of the FEEDCTL controller requires the following interpretation of the input data. W1 and W2 contain CNTRLVAR and ccc (or cccc), respectively, where ccc (or cccc) is a CONSTANT type control element. This constant would be the desired (setpoint) steam generator secondary side water level. The latter may be expressed alternatively as a desired secondary coolant mass or as a differential pressure measured between two locations in the steam generator downcomer. W3 and W4 would contain CNTRLVAR and ccc (or cccc), respectively, where ccc (or cccc) is the number of the control component that describes the summing algorithm to compute the sensed variable (e.g., collapsed water level may be computed by summing the product of VOIDF and volume length over the control volumes in the riser section). W5 is the S_k value used to divide the difference between the desired (setpoint) and sensed water level to produce the first portion of the error signal E_3. W6 is MFLOWJ, and W7 is the junction number of the steam exit junction from the steam generator. W8 is MFLOWJ, and W9 is the junction number of the feedwater inlet junction. W10 is the S_m value used to divide the difference between the sensed steam flow and sensed feedwater flow to produce the second portion of the error signal E_3. E_3 must be initially zero if it is intended to have the controller output remain constant as long as the input quantities remain constant. W11 and W12 are the T_6 and T_5 values, respectively. All variables having units must be in SI units.

A15 CARDS 1001 THROUGH 1999, STRIP REQUEST DATA

These cards are required only in STRIP-type problems. One or more cards are entered, each card containing one variable request. Card numbers need not be consecutive. Variables are ordered on the STRIPF file in the order of increasing card numbers. If an incorrect variable request code is entered, the value will be 0.0. It is not flagged as an input error, since at some later time in the transient, a renodalization may result in the variable request code becoming correct.

W1(A) Alphanumeric part of the variable request code.

W2(I) Integer part of the variable request code.

A16 CARDS 1001 THROUGH 1999, COMPARE DUMP FILES CONTROL DATA

These cards are required only in CMPCOMS problems. One or more cards are entered, each card containing one request to compare dump blocks on the files specified with the -A and -B options on the command line. Card numbers need not be consecutive.

W1(I) Dump file number from file specified on -A command line option.

W2(I) Dump file number from file specified on -B command line option.

The values in Words 1 and 2 on a succeeding card must be greater than the values on the preceding card. The values in Words 1 and 2 are the advancement number when the dump block was written. This information is written as a line in the printed output of the run writing the dump file. The form of the line is, "---Dmpcom no. nnn written, block no. mmm on unit u---," where nnn is the advancement count number, mmm is the count of the number of blocks written, and u is A or B indicating the file specified by the -A or -B option.

A17 RELAP5-BASED CODE OPERATING PROCEDURES

When operating on Unix systems, the RELAP5-based program can interpret a Unix-style command line. The command line below is written with all of the allowed options (prefixed by a minus sign), and each option is followed by its default value.

relap5.x -f ftb1 -i indta -o outdta -p plotfl -r rstplt -s stripf -j jbinfo \

-n null -c cdffile -a coupfl -X -C 0 -A dumpfil1 -B dumpfil2 \

-w tpfh2o -d tpfd2o

If an option and its parameter are not entered, the default is used. With the exception of the X option, an option character must always be followed with a file name, and an option may not be repeated. The f option specifies a scratch word addressable file used only on CRAY versions. This file is a word addressable file, and the I/O is done by CRAY library subroutines that have successfully resisted external open and close statements. This file is small and can fit in most directories. This file should be removed after execution, but no error occurs in subsequent calculations if it is not removed. The file indta contains input data, outdta contains printed output, plotfl contains plotter information, rstplt is the restart plot file, and stripf is the strip file. The files dumpfil1 and dumpfil2 are files used to dump common and dynamic blocks for debugging purposes. The files beginning with tpf (e.g., tpfh2o) are thermodynamic property files where the characters following the tpf are chemical names of the material. The RELAP5 code uses only the light and heavy water (h_2o and d_2o) materials. The file jbinfo is an optional file created by the user who wishes to place some additional information on his output file (such as a listing of the control cards used to run the job). The indta file must be available and the outdta file must not exist, or else a diagnostic message followed by immediate termination will follow. The rstplt must not exist for a NEW problem and must exist for other type problems. The dumpfil1 and dumpfil2 must not exist for the run that creates them and must exist for the CMPCOMS run. Most of the other options are for operation with the Nuclear Plant Analyzer (NPA).

The command line capability eliminates the need to have all files needed for execution in the same directory or to copy/rename files to match the default names. For example, the command:
relap5.x -i myprob.i -o /usr/tmp/rjw/myprob.o \

-r /usr/tmp/rjw/myprob.r -w /u2/rjw/relap5/tpfh2o

takes the executable file and input file from the current directory, uses a temporary disk for the output and restart-plot files, and uses a water property file from a different directory.

For operating systems other than UNIX, the default file names must be used.